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EDITED BY J. McKEEN CATTELL

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The author endeavors to present the results of experience in researches aimed first at the discovery of the way and conditions of life of animals in nature and then at their transplantation into the laboratory for scientific control in experiments simulating natural conditions as closely as possible.

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Systematic Psychology: Prolegomena. EDWARD B. TITCHENER. xi + 278. pp. $2.50. Macmillan Company.

This volume was intended to form the introductory volume to the author's long-projected and never-finished work on Systematic Psychology. Most of it has been reprinted from *The American Journal of Psychology*.

Personality and the Social Group. Edited by ERNEST W. BURGESS. xii + 230 pp. $3.00. University of Chicago Press.

In this volume are brought together the research of men in social psychology and sociology who are now studying personality from a new point of view, as a product of group life.

THE SCIENTIFIC MONTHLY

SEPTEMBER, 1929

ARCHEOLOGICAL EVIDENCES OF THE ANTIQUITY OF DISEASE IN SOUTH AMERICA

By Professor ROY L. MOODIE
SANTA MONICA, CALIFORNIA

INTRODUCTION

ALTHOUGH the territory now included within Peru has furnished the majority of the evidences of the ills and accidents to which the ancient South Americans were liable, yet there are in other parts of the continent traces of prehistoric diseases.[1] These scant evidences have been reviewed[2] elsewhere and we may restrict our attention in this place to the more abundant evidences presented by archeological discoveries in the territory in and around Peru.[3,4,5]

[1] R. Verneau. 1903. "Les anciens Patagons." Contribution a l'étude des races précolombiennes de l'Amérique du Sud. Monaco, pp. 1–342, figs. 1–68, pls. I–xv. Lesions pathologiques, pl. x.

[2] Roy L. Moodie. 1923. "Paleopathology." Urbana, pp. 1–567, plates i–cxvii, 49 text-figs. A review of the evidences of disease and injury from early geological time down to about A. D. 600. Chapter XV reviews the evidences from South America.

[3] Frank Albert Burton. 1927. "Some Considerations on Prehistoric Aural, Nasal, Sinus Pathology and Surgery." El Palacio Press, Santa Fé, pp. 1–38, figs. 1–17.

This important study is based on the collection of pre-Columbian Peruvian material at the San Diego Museum, assembled by Dr. Aleš Hrdlička. The author, a practicing surgeon of San Diego, discusses diseases and surgical operations on the ear, eye, nose and mouth, illustrating his discussion by good, enlarged photographs of the prehistoric material.

The prehistory of the Peruvian area is one of fascinating interest.[6] In this region people of diverse cultures have lived for thousands of years.[7,8] Dynas-

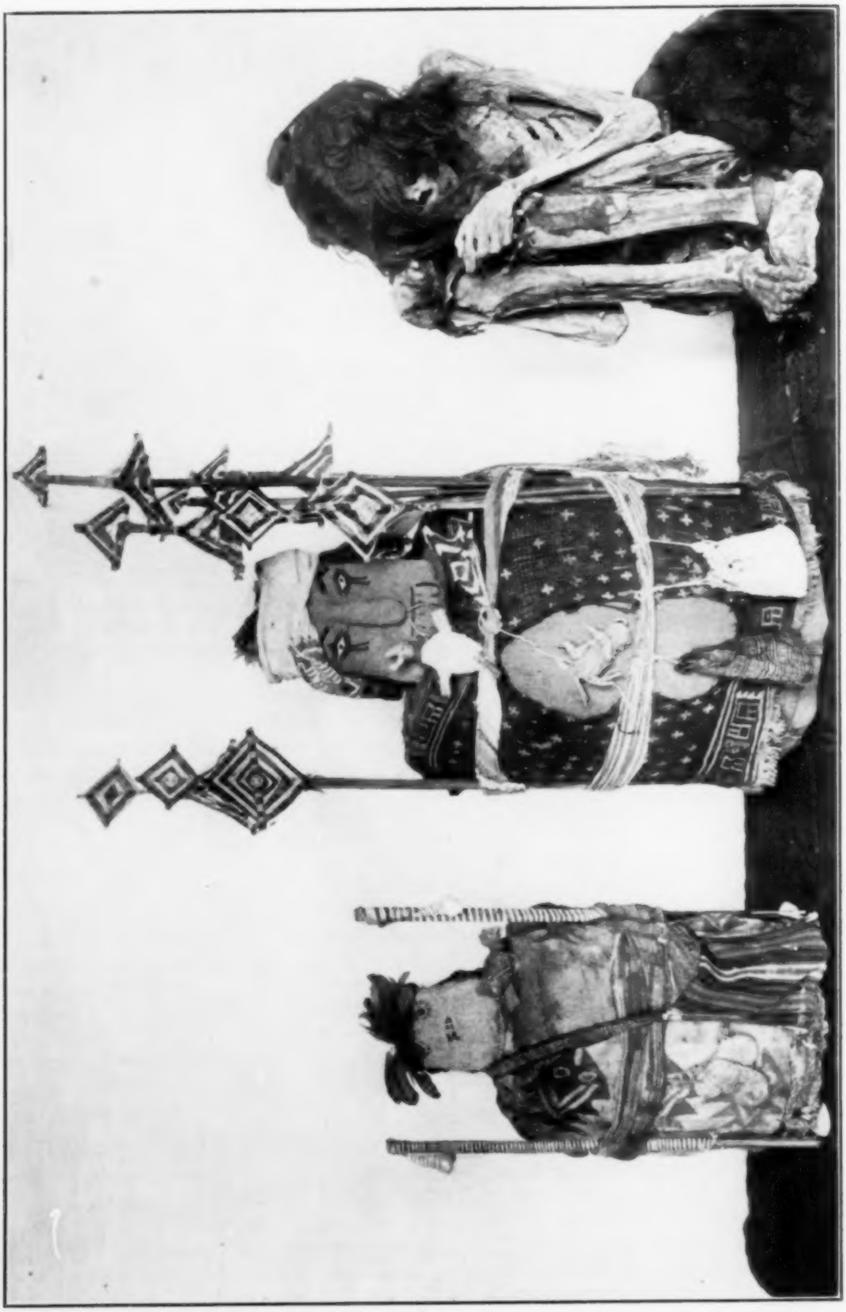
[4] Field Museum of Natural History has an extensive program of study under way, dealing with the prehistoric mummies in its collections. A part of this work is the interpretation of evidences of disease from numerous, large-sized Röntgenograms of the unopened mummy packs, which has been undertaken by the author.

[5] R. L. Moodie. 1926. "Tumors of the Head among Pre-Columbian Peruvians," *Annals of Medical History*, 8: 394–412, 15 figures. 1927. "Injuries to the Head among Pre-Columbian Peruvians," pp. 298–328, figures 1–22.

[6] W. Reiss and A. Stübel. 1880–1887. "The Necropolis of Ancon in Peru." A contribution to our knowledge of the culture and industries of the Empire of the Incas, being the results of excavations made on the spot. Translated by Professor A. H. Keane. Three large, sumptuous, folio volumes, illustrated by colored lithographic plates. The most extensive account of ancient mummies which has appeared.

[7] A. L. Kroeber and his associates have published, 1924–27, important discussions of the Max Uhle collections of prehistoric potteries, furnishing for the first time a reliable basis for a chronology of pre-Columbian events. Seven contributions have been issued as University of California Publications in American Archeology and Ethnology.

[8] G. G. MacCurdy. 1923. "Human Skeletal Remains from the Highlands of Peru," *American Journal of Physical Anthropology*, 6, no. 3, pp. 218–329, pls. I–xlix. Papers 8 and 10 deal



—*Courtesy of the American Museum of Natural History*

FIG. 1. THREE PREHISTORIC PERUVIAN MUMMIES FROM ANCIENT CEMETERIES

—*Courtesy of the American Museum of Natural History*

FIG. 2. AN ELABORATELY EQUIPPED, COMPLETE MUMMY-PACK

WITH FALSE HEAD, FROM TRUJILLO, NEAR RUINS OF CHAN-CHAN, PERU. THE FOLDED MUMMY IS WITHIN THE LOWER PART OF PACKAGE.

FIG. 3. MUMMY-PACK

FROM THE FAMOUS NECROPOLIS AT ANCON, PERU, WHICH HAS YIELDED GREAT NUMBERS OF DIVERSIFIED SPECIMENS. THIS ONE, WRAPPED IN CLOTH AND SKINS, CARELESSLY TIED IN A LOOSE, IRREGULAR NETWORK OF HEAVY CORD, IS AN INTERESTING EXAMPLE OF COMMON TYPE OF PACK. ON THE LEFT ARE TWO REEDS WRAPPED WITH THREAD, AND THE BAG, NOW TORN, DOUBTLESS CONTAINED WEAVING MATERIALS. THIS SPECIMEN, NO. 5913, FIELD MUSEUM OF NATURAL HISTORY, IS TWENTY-THREE INCHES LONG, EIGHTEEN INCHES WIDE, WITH A DEPTH OF SIXTEEN INCHES. COLLECTED BY GEORGE A. DORSEY.

ties grew and waned centuries before recorded history, and it is the task of the prehistorian to puzzle out, from the material at hand, the details of the daily life[9, 9a] of those ancient and interesting people.

RUINS

Some of their ruins[8] are notable either in point of size or massiveness of con-

with the evidences seen on skeletal material collected in conjunction with the exploration of Machu Picchu, by Yale University. These are the best anthropological papers on pre-Columbian Peruvians within recent years.

9 Leonard Freeman. 1924. "Surgery of the Ancient Inhabitants of the Americas," *Art and Archeology*, 18: 21–35, figs. 1–24. The author, a surgeon in Denver, presents the best general account of the subject so far published. His material was largely that preserved in the San Diego Museum.

9a Garcilasso de la Vega, son of an Inca princess and a Spanish father, after many years of residence in Spain, wrote largely from memory, tradition and writings of contemporaries, his "Royal Commentaries," which give helpful sidelights on the life of the ancient Andeans.

FIG. 4. PREHISTORIC MUMMY-PACK FROM ICA VALLEY, PERU
CLOTH COVERING DISINTEGRATING. MUSEUM OF ANTHROPOLOGY, UNIVERSITY OF CALIFORNIA. COLLECTED BY MAX UHLE.

struction. The city of Chan-Chan, covering eleven square miles, is thought to have had a population of hundreds of thousands. Its sixty-foot protecting wall is now reduced to mounds of earth by centuries of erosion.

Among these ruins, opened through the centuries by treasure hunters, occur the potteries, the implements, the mummies and other archeological objects on which is founded our knowledge of the antiquity of disease in this area. Vandalism[7] still goes on, in spite of legal restrictions. Mummies, wrapped and unwrapped, bones, potteries and other objects are thrown carelessly aside or broken open in the search for treasure. From this discarded material have been secured the evidences for the antiquity of disease in this part of South America.

MUMMIES

Among the archeological objects examined for this purpose the mummies

are, of course, the most important. Many of the known mummies were carefully prepared by drying[9a] and wrapped in skins or cloths and were bound, more or less neatly, with woolen cords.[6] Wallis Budge has estimated that of the millions of people who lived in Egypt while embalming was in vogue probably not more than a hundred thousand were embalmed. Mummies were expensive and only the rich could have their bodies prepared for resurrection and life eternal with Osiris. It is possible that a similar ratio obtained among the ancient Andeans. The museums of the world possess only a few hundred. A few thousand have been destroyed by treasure hunters, and an untold number remain buried. The vast majority of the population is still to be accounted for.

Mummies which were thrown aside by vandals soon lost their coverings of cloth and dry skin, leaving their bones to exhibit such evidences of disease[5] as may have made permanent alterations in the structure of the bones. Unwrapped mummy-packs may be examined by means of the X-ray;[4] which reveals most of the diseased alterations of the skeleton, and some of the soft parts. Scores of prehistoric mummy-packs (Fig. 20) have been thus examined, and will soon be described.

The details of the preparation of the dead for burial both in the Andean highlands and along the coast are still to be determined. Sun drying, both in the mountains and along the coast, seems to have been most prevalent and we do not know that the abdomen was ever opened, although their skilled surgeons had no hesitancy in opening the head.[9, 10]

Some of the mummies discovered in the necropolis at Ancon[6] are wrapped in fine skins (Fig. 3) or gorgeously colored

—Courtesy Field Museum of Natural History

FIG. 5. MUMMY-PACK OF PLAITED STRAW

OPEN IN FRONT OF FACE. COLLECTED BY EMILIO MONTE AT CUZCO, PERU. LENGTH OF PACKAGE, THIRTY-THREE INCHES; WIDTH FOURTEEN AND ONE HALF INCHES; DEPTH FIFTEEN INCHES. (NO. 3522, FIELD MUSEUM OF NATURAL HISTORY.)

cloths, the colors bright and fresh (Fig. 1) after centuries in the sands. Often more than one body[11] is enclosed in a single pack (Fig. 7). Sometimes the false head is placed on the wrong end of

10 G. G. MacCurdy. 1918. "Surgery among Ancient Peruvians," *Art and Archeology*, pp. 381–395, illus.

11 Arthur Baessler. 1906. "Peruanische Mumien." Untersuchungen mit X-Strahlen. Taf. 1–15.

FIG. 6. PREHISTORIC INFANT MUMMIES

ARE ABUNDANT IN PERUVIAN BURIALS. THIS BABY, IN ITS ORIGINAL NATIVE-CLOTH WRAPPING, IS AN EXAMPLE OF NATURAL MUMMIFICATION. COLLECTED AT LUPO, NEAR HUAROCHIRI, PERU, BY ALEŠ HRDLIČKA. NO. 1149, SAN DIEGO MUSEUM.

—*After Baessler*

FIG. 7. A RÖNTGENOGRAM OF AN ANCIENT PERUVIAN MUMMY-PACK

SHOWING THREE BODIES WITH METAL OBJECTS NEAR THE HEADS. THE BODIES ARE ALL FOLDED AND PLACED CLOSE TOGETHER.

the package. In the mountains near Cuzco bodies were enclosed in neatly woven cases of straw or twigs (Fig. 5), or both, with an aperture for the face. Infant bodies were often carelessly wrapped in coarse cloth (Fig. 6) and tied in a negligent manner with heavy cord. Naked mummies, folded, are frequently found in a good state of preservation.

It is possible, after soaking in weak formalin solution, to identify muscles, nerves, tendons, arteries and other organs[12] in limbs of bodies many centuries old. Microscopic examination of the tissues reveals cells and their nuclei, blood corpuscles, connective and fatty tissues, and in certain areas elastic fibers.[12] The walls of an artery from the leg show evidences of disease. Often in the many Röntgenograms examined shadows of intestines, liver and spleen are seen.

[12] H. U. Williams. 1927. "Gross and Microscopic Anatomy of Two Peruvian Mummies." *Archives of Pathology and Laboratory Medicine*, 4: 26–33.

—*Courtesy of the American Museum of Natural History*

FIG. 8. PREHISTORIC PERUVIAN POTTERY SHOWING EVIDENCES OF DISEASE

Left: VESSEL IN THE FORM OF A HUMAN HEAD, WITH EAR ORNAMENTS. THE SWELLING ON THE NOSE IS A DISEASE KNOWN AS *goundou*, KNOWN TO-DAY FROM MELANESIA AND WEST AFRICA. *Middle:* RED JAR SHOWING HUMAN FIGURE WEARING A WHITE GARMENT. UNIDENTIFIED IMPLEMENT IN HANDS. HANDLE MISSING. MOUTH SHOWING RAVAGES OF THE DISEASE *uta* CAUSED BY A PROTOZOAN PARASITE OF THE BLOOD. *Right:* JAR OF HUMAN FIGURE, LYING ON STOMACH, SHOWING DISEASED LIPS AND NOSE. HANDS CLASPED.

—*Courtesy of the American Museum of Natural History*

FIG. 9. PREHISTORIC PERUVIAN POTTERY SHOWING EVIDENCES OF DISEASE

Left: DOUBLE-SPOUTED JAR SHOWING HUMAN FIGURE WITH DISEASED MOUTH, *uta* A PHASE OF LEISHMANIASIS. VESSEL EIGHT AND THREE FOURTH INCHES HIGH. *Middle:* RED AND WHITE JAR SHOWING HUMAN FIGURE WITH DISEASE OF THE MOUTH. THE ATTITUDE IS THAT OF A HUNCHBACK. *Right:* JAR SHOWING HUMAN FIGURE WITH DISEASED MOUTH.

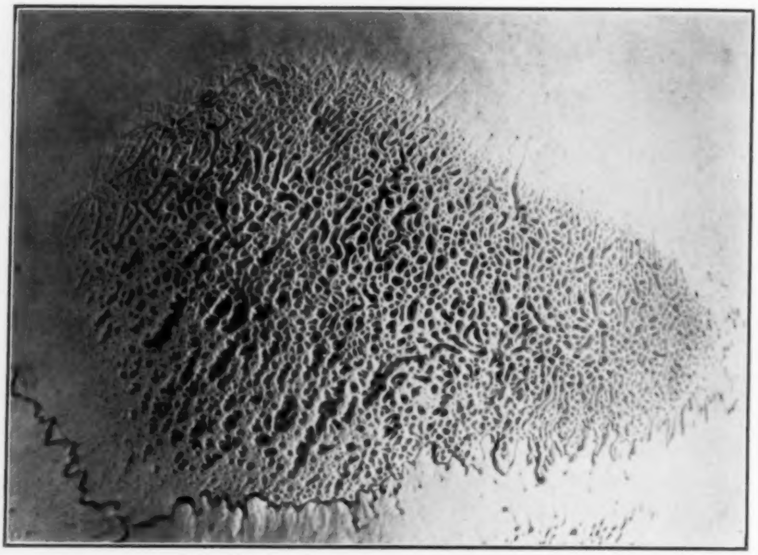


FIG. 10. THE IVORY-LIKE LUSTER OF THE SKULL

INDICATES A HEALTHFUL CONDITION OF THE BONES AT THE TIME OF DEATH. SKULL NO. 147, SAN DIEGO MUSEUM. MANY OF THE YOUTHFUL MUMMIES REVEAL THE HEALED EVIDENCES OF A NUTRITIONAL DISEASE IN CHILDHOOD.

POTTERIES

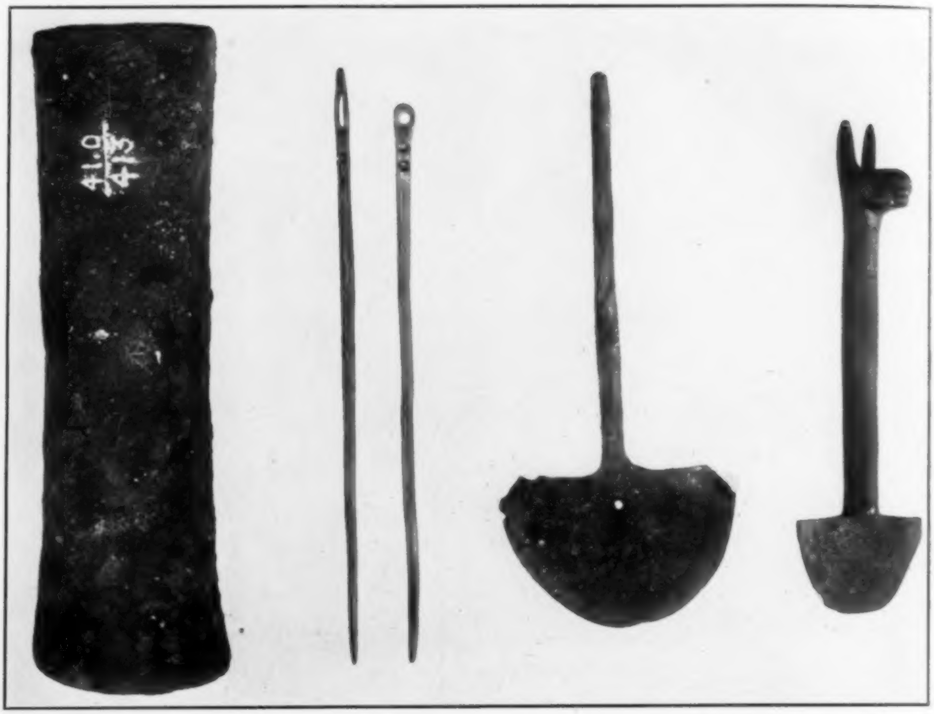
It was a wide-spread custom in prehistoric times in the Peruvian area to depict on their abundant potteries[7] many of the intimate details of the daily life of the people, their food, their fauna and flora, their portraits, pugilistic encounters and often their bodily struggles with disease. Many of these jars have a considerable antiquity. By far the most prevalent disorder represented is a loathsome affliction, by a blood parasite, of the mouth and nose—the disease being known as *uta*. It is depicted on the features of several of the potteries shown in Figs. 8 and 9. The skull shown at the bottom of Fig. 24 shows the effects of the disease, and the evenness of the wound suggests that an ancient surgeon may have excised the diseased parts with an obsidian flake in an effort to arrest the progress of the disease. A rare disease, *goundou*, otherwise unknown in the western hemisphere, is indicated by the pottery to the left in Fig. 8. Other manifestations of disease and of surgical interference are depicted on similar water jars. A direful skin disease, *Veruga peruana*, is thus shown.

PEDIATRICS

The diseases of childhood among the ancient nations must have been many and severe, if we may judge from the numerous infant mummies, but few of the diseases were such as to leave traces on the bones. Rickets, apparently, did not exist among the ancient Andeans, since no traces of its manifestations have been seen in an examination, by X-ray,[4] of numerous mummy-packs. One disease of infancy, a nutritional disorder, leaves its effects (Fig. 10) in paired lesions of the roof of the orbit or on the bones of the cranial vault. The effects of this disease, known as *Osteoporosis* or *Cribra cranii*, always remain after healing, as sieve-like patches (Fig. 10).

FIG. 11. AN ADULT FEMALE SKULL

PRESENTS A HUGE *Hyperostosis cranii* DUE TO THE PRESSURE OF A TUMOR OF THE BRAIN MEMBRANES. THE TUMOROUS MASS WAS OF SLOW GROWTH AND GAVE A CURIOUS, LOP-SIDED APPEARANCE TO THE HEAD. No. 158, SAN DIEGO MUSEUM.



—*Courtesy of the American Museum of Natural History*

FIG. 12. PREHISTORIC COPPER AND BRONZE IMPLEMENTS

FROM THE ANDEAN HIGHLANDS. MODIFICATIONS OF SOME OF THESE MAY HAVE SERVED FOR SURGICAL PURPOSES. *Left to right:* A BROAD COPPER OR BRONZE BLADE; A COPPER NEEDLE FROM AN EXCAVATION NEAR LLAYAYLL, LAKE TITICACA; A COPPER NEEDLE FROM KASAPATA; A COPPER PIN OR TOPO, CERROCA, BOLIVIA; A COPPER KNIFE, SHORT BLADE, WITH HEAD OF LLAMA ON THE HANDLE.

Hydrocephalus is suggested by the shape of the skull of several ancient infant mummies.

TUMORS

There are numerous instances of the presence of tumors[5] in ancient Peru, mostly of the benign type, slow-growing and often not bothersome at all. Of this type are the ivory-like osteomata of the cranial vault and on the jaw. Bony tumors, of huge growth, due to irritation from tumors in the brain membranes (Fig. 11) are sometimes found in the heads of ancient mummies. Soft tumors, of unknown type, often leave their marks of pressure atrophy on the osseous parts.

DISEASES OF THE TEETH

The prehistoric peoples whose ills we are following suffered from a variety of dental troubles—with not a dentist to relieve them.[8] Cavity formation through caries (Figs. 15, 16), while abundant, was not nearly so prevalent as the ravages of pyorrhea. Often all teeth are lost because of this disease (Figs. 14, 17). Following upon excessive deposits of salivary calculus (tartar) pyorrhea reduced the efficiency of the teeth (Figs. 15, 16) and added bodily troubles. Abscesses (Fig. 16) were common and wide-spread, often of enormous proportions, infecting the air sinuses and spreading into the ears and mastoids.

Supernumerary and misplaced teeth (Figs. 16, 18) were not at all common.

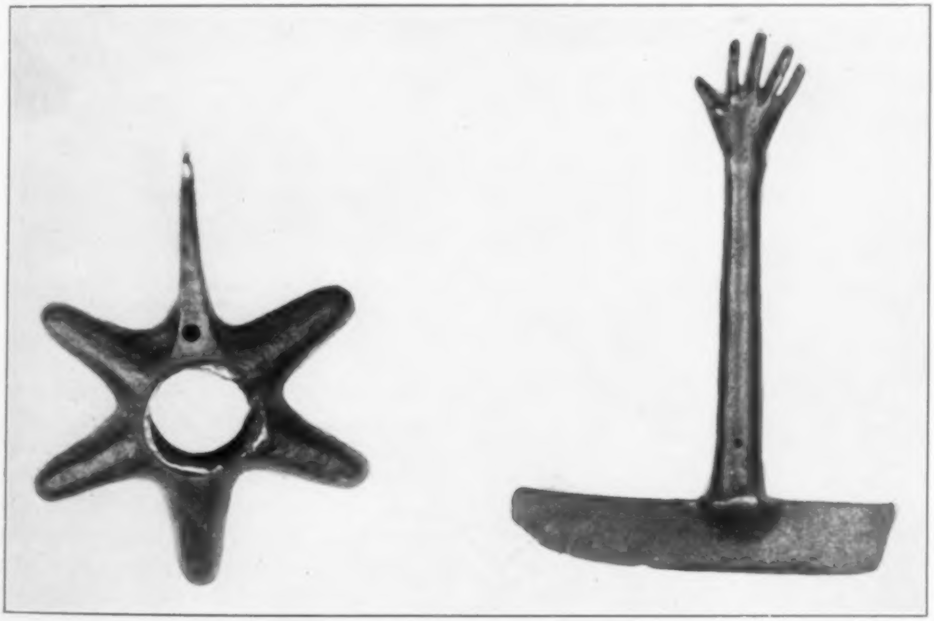
INJURIES

Accidental and intentional wounds, particularly of the head,[5] were common, especially in the highlands. Some of these (Figs. 19, 23) produced by a heavy mace (Fig. 13) were immediately fatal. Others (Fig. 19), produced by sling shot, were less frequently fatal, producing depressed fractures which were relieved by trephining. Smashing blows from a heavy club are often seen to have distorted the features greatly, or to have produced a set of radiating linear fractures (Fig. 23). Broken limb bones were crudely set, or healed as best they could without interference.

SURGERY

It may be that surgical interference, in prehistoric times, developed out of attempts to aid the wounded. Most of their surgical practices[3, 9, 10, 13] were restricted to operations on the head. Of these the art of trephining was the one most commonly followed. So much has been written on prehistoric trephining that we may well be brief here. Trephinings by sawing, scraping, cutting and drilling were followed. The location and extent of the injury determined the site of the operation and the method followed. Fig. 21 shows the details of two of these methods. The upper wound, made by cutting above the orbit,[3] was made to drain a frontal sinus infection. The opening in the lower figure must have been a post-mortem practice operation, since its location on top of the

[13] R. L. Moodie, "Surgery in pre-Columbian Peru." In press. 65 figures. 1928. "The Paleopathology of Patagonia," *Annals of Medical History*, Sept.



—*Courtesy of the American Museum of Natural History*

FIG. 13. PREHISTORIC PERUVIAN INSTRUMENTS

Left: COMBINED COPPER, STAR-SHAPED MACE AND AXE. *Right:* KNIFE, WITH HUMAN HAND FOR HANDLE.

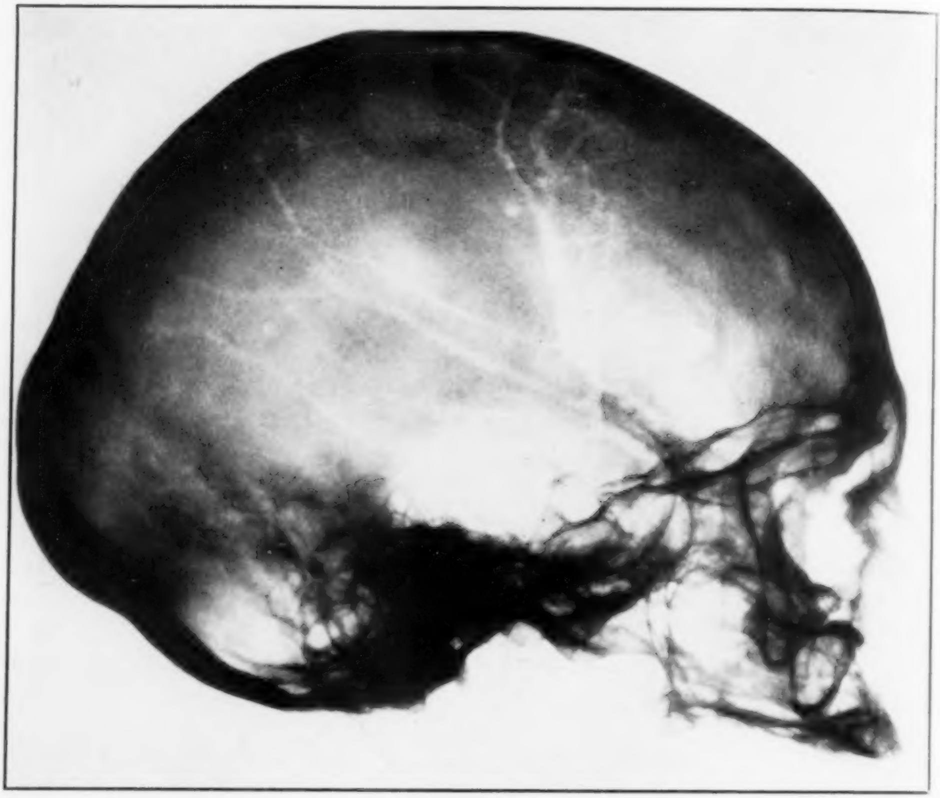


FIG. 14. RÖNTGENOGRAM OF ANCIENT PERUVIAN SKULL

OF A MALE FROM NASCA, PERU, SHOWING LOSS OF ALL TEETH THROUGH DISEASE. NO. 185, SAN DIEGO MUSEUM.

head, with an unusually thick skull, renders it improbable that there could have been an injury. A single skull shows (Fig. 22) what may have been a surgical bandage.[14] The application of heat was practiced as a counter-irritant. Excisions of diseased parts, the opening of abscesses and possibly phlebotomy were known and practiced. Primitive instruments, either of volcanic glass or copper utensils (Figs. 12, 13) served the primitive surgeon. The application of splints in fractures of long bones was unknown.

DEAFNESS

Ear troubles in prehistoric times were prevalent and are to be associated with infections from the teeth reaching the middle ear by way of the paranasal sinuses, or from the nose following the same route. Large exostosial, ivory-like growths in the outer passage interfered with or prevented hearing. The outer passage is often closed by a thickening of the walls of the meatus, as well as by osseous changes in the walls of the cochlea.

14 R. L. Moodie. 1926. "A Prehistoric Surgical Bandage from Peru," *Annals of Medical History*, 8: 69–72. Illus.

No trace of syphilis in prehistoric times has yet been found in South America.[15]

CHRONOLOGY

It is not yet possible to assign accurate dates to prehistoric events in South America. We must speak somewhat vaguely of the antiquity of civilizations in the Andean regions in terms of thousands of years, and we must date the age of potteries and mummies as that of hundreds of years ago. The prehistoric era closes at about A. D. 1530, the time of the Spanish conquest. It seems probable that there has been a continuous settlement at or near to Ancon,

FIG. 15. DISEASES OF THE TEETH OF ANCIENT PERUVIANS

Upper: PALATE OF SKULL No. 125, SAN DIEGO MUSEUM, FROM CINCO CERROS, PERU, SHOWING DISEASED CONDITION OF THE SOCKETS, THE BONY PALATE, AND A CARIOUS CAVITY ON THE RIGHT. *Lower:* TEETH ENCRUSTED WITH SALIVARY CALCULUS, "TARTAR," WITH EVIDENCES, IN THE EXPOSED ROOTS, OF PYORRHEA.

[15] H. U. Williams. 1927. "The American Origin of Syphilis," *Archives of Dermatology and Syphilology,* 16: 683–696.

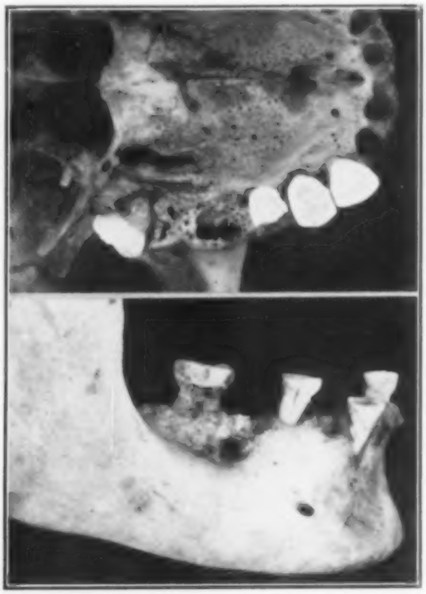


FIG. 16. DISEASES OF THE TEETH

Upper: POST-COLUMBIAN MALE, FROM CHAVINA, PERU. *Lower:* PYORRHEA AND CARIES HAVE BEEN ACTIVE.

FIG. 17. AN EDENTULOUS PALATE

WITH LOSS OF ALL TEETH DUE TO DISEASE.

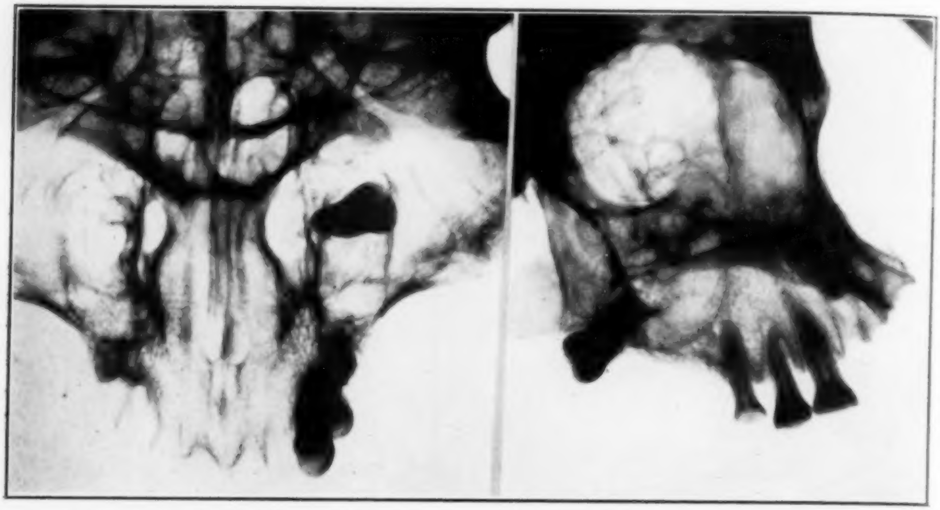
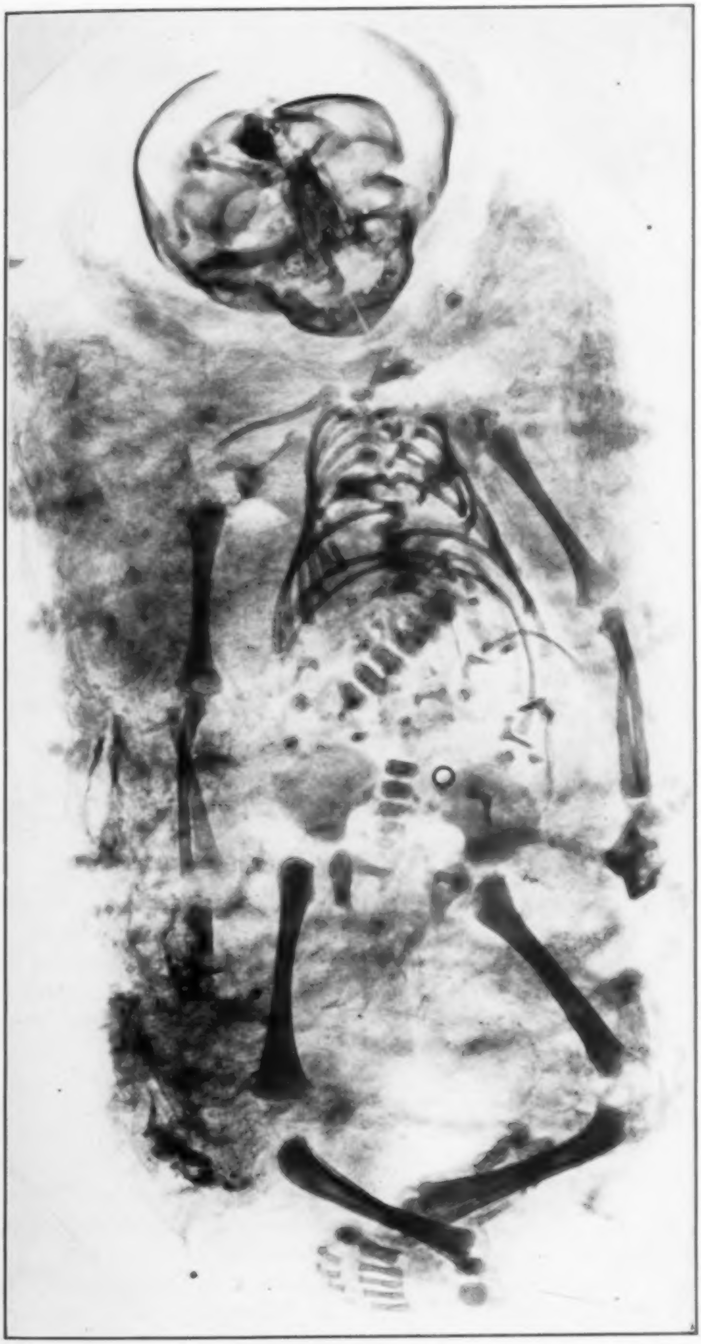


FIG. 18. RÖNTGENOGRAMS OF THE MAXILLARY REGION
OF SKULL NO. 209, SAN DIEGO MUSEUM (SEE FIG. 16), A POST-COLUMBIAN MALE FROM CHAVINA, PERU, SHOWING CONDITIONS OF TEETH AND SURROUNDING BONE. *Left:* PALATE FROM BELOW. *Right:* MAXILLA FROM RIGHT.

FIG. 19. INJURIES RESPONSIBLE FOR THE DEVELOPMENT OF "TREPHINING"
IN ANCIENT PERU. *Left:* SLING-SHOT INJURY WITH DESCENDING LINEAR FRACTURE TO ORBIT, PRODUCING A DEPRESSED FRACTURE, RELIEVED BY TREPHINING. *Right:* SKULL NO. 42, SAN DIEGO MUSEUM, FROM HUACHO, PERU, SHOWING TWO SLING-SHOT INJURIES, ABOVE, AND A HUGE, MORTAL INJURY FROM A MACE, BELOW.



—*Courtesy of the Field Museum of Natural History*

FIG. 20. RÖNTGENOGRAM OF AN INFANT MUMMY

FROM PERU, SHOWING WHAT PERFECT DETAIL THESE ANCIENT BODIES MAY POSSESS. THE EXTENDED SKELETON IS, APPARENTLY, FREE FROM DISEASE. RICKETS IS UNKNOWN IN PREHISTORIC PERU. X-RAYS DO NOT REVEAL ANY OF THE RAVAGES OF THE NUTRITIONAL DISTURBANCES.

Peru, for the past two thousand years. The chronology of Peru is being developed at Lima by Julio C. Tello by the

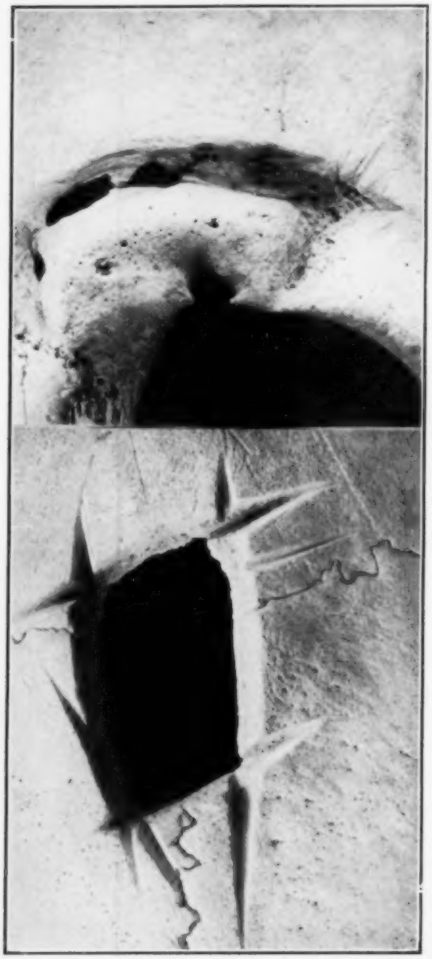


FIG. 21. ANCIENT PERUVIAN SURGEONS TREPHINED THE SKULL

IN SEVERAL WAYS, SAWING, SCRAPING, CUTTING, DRILLING AND BY COMBINATIONS OF THESE METHODS. *Above:* OPENING OF THE FRONTAL SINUS BY CUTTING, ABOVE THE ORBIT, IN SKULL NO. 288, SAN DIEGO MUSEUM, MALE FROM CINCO CERROS. POSSIBLY FOR RELIEF OF SINUS HEADACHE. *Below:* OPENING MADE BY SAWING WITH A ROUGH-EDGED FLAKE OF OBSIDIAN, IN SKULL NO. 308, SAN DIEGO MUSEUM, A FEMALE FROM SAN DAMIAN, PERU, NEAR CINCO CERROS.

FIG. 22. A SURGICAL BANDAGE

OF NATIVE COTTON CLOTH, ON THE HEAD OF A MUMMY FROM LOMAS, PERU, COLLECTED BY ALEŠ HRDLIČKA (NO. 658, SAN DIEGO MUSEUM). THE BANDAGE IS HELD IN PLACE BY WOOLEN CORDS, SIMILAR TO THOSE USED IN MAKING THE QUIPU.

accumulation of data and materials at the anthropological and archeological museum and at San Marcos University.

SUMMARY

The majority of the evidences of disease in South America, during prehistoric times, is obtained from pictorial representations on potteries, some of which are many centuries old, and from mummies and skeletal parts derived from mummies. Most of this material is the result of vandalism, but some scientific collecting has been done, first by Reiss and Stübel,[6] then by Max Uhle,[7] and more recently by Kroeber for Field Museum, and by Tello in Lima. Unopened mummy-packs, examined by the X-ray, have furnished a great deal of the evidences, and skeletal parts, largely derived from mummies, have shown the alterations of disease and injury.

Among the abundant infant mummies no traces of rickets are found. Other diseases of childhood are seen. Diseases of the teeth, especially pyorrhea, are common. Many injuries due to war are

FIG. 23. TWO ANCIENT PERUVIAN SKULLS SHOWING INJURIES

Above: Skull No. 23, San Diego Museum, from Cinco Cerros, showing two huge mace (?) injuries. *Below:* Skull No. 21, San Diego Museum, from San Damian, showing effects of a crushing blow from a club, with radiating fractures.

FIG. 24. ANCIENT SURGERY

Above: A large trephined opening, made by straight and curved cutting, in a female skull, No. 257, San Diego Museum, from Cinco Cerros, Peru. *Below:* It looks as if the surgeon had cut away the parts diseased by *uta*. Skull No. 86, San Diego Museum, from Chavina, Peru.

found. Surgery, particularly trephining, was well established. Deafness was due to a number of causes. It will be possible to determine the diseases of the soft tissues by microscopical examination of specially prepared material.

NEW DATA ON THE ORIGIN AND SPREAD OF THE DOLLAR MARK

By Professor FLORIAN CAJORI

UNIVERSITY OF CALIFORNIA

THE examination of manuscripts in the Bancroft Library of the University of California has supplied data which lead to a fuller grasp of the, for so long, elusive knowledge of the origin and spread of that symbol which came to represent the monetary unit now dominant in the financial affairs of the world. It is well known that the United States dollar was adopted in 1785 and was modeled on the average weight of the Spanish coin then in circulation. Thomas Jefferson speaks of the dollar as "a known coin, and most familiar of all to the minds of the people."[1] The first United States dollars were coined in 1794. Jefferson does not use the dollar symbol $, or make reference to it. We shall see that its first occurrence antedates 1785.

There exist a dozen or more theories on the origin of the dollar mark. All of them are such stuff as dreams are made of. If ever the need of painstaking empirical study presents itself in the history of symbols, it is in the origin of our $. The student of chemistry and physics is not the only investigator who must subject himself to the reign of fact. When asked to submit evidence drawn from early manuscripts, the proponents of the theory that found the origin of $ in the superposition of the letters U and S (the "U. S. theory")[2] take to flight. The same is true of the advocates of the theories which ascribe the origin to the monogrammatic form[3] of I H S (often erroneously interpreted as *Jesus, Hominum Salvator*) or to H S and I I S that were abbreviations used by the Romans for a coin called sestertius,[4] or to the "pillars of Hercules" that were impressed upon the "pillar dollar"[5] of the seventeenth and eighteenth centuries, or to the figure 8 combined with a vertical bar | or with the solidus /, or with the letter P, or with the letter R, because the Spanish dollar was known as a "piece of eight"[6] or as "8 reales."

A theory which possesses great antecedent probability explains the origin of our $ from the Portuguese symbol for "thousands" which is shaped like our dollar mark. A number which we write 13,765, the Portuguese wrote 13$765. Here the $, called "cifrão," takes the place of the comma, separating hundreds from thousands. This separating is done for convenience in the reading of numbers. The "cifrão" came to be used more especially in the designation of monetary values, as in 1.043:381$000 *reis* or 1.043:381$ *milreis*. The theory supposes that the Portuguese "cifrão" was assigned the new rôle of representing the Mexican "peso" or "piastre," and to have been adopted later in the United States as our "dollar" mark. Proofs from manuscript evidence that such a change actually did take place

1 D. K. Watson, "History of American Coinage," 1899, p. 15.

2 *Notes and Queries* (Fifth Ser.), London, Vol. VI, 1876, pp. 386, 434.

3 Standard Dictionary, 1896, article, "Dollar."

4 M. Townsend, "U. S. an Index, etc.," Boston, 1890, p. 420.

5 *Notes and Queries*, London (Fifth Ser.), Vol. VII, 1877, p. 155, 317; New American Cyclopedia, Vol. VI, 1859, article, "Dollar"; W. L. Fawcett, "Gold and Debt," Chicago, 1877, p. 13.

6 M. Townsend, *op. cit.*, p. 420; *Scribner's Magazine*, 1907, 42: 515; Webster's Unabridged Dictionary, in the editions since 1864.

have never been attempted in print. The writer has examined many books and many manuscripts, but has not found the slightest evidence in support of this hypothesis. Moreover, Americans who are known to have used the dollar mark in the eighteenth century were not in contact with the Portuguese. There were no Portuguese settlements in North America. Portuguese silver money coined in Brazil did not in the eighteenth century circulate in the American colonies, nor, so far as we are able to ascertain, in the West Indies or the Gulf coast. There is no evidence that the name "milreis" or the name "cifrão" ever came to be synonymous with "dollar," or "peso." The cifrão hypothesis must therefore be abandoned in favor of another hypothesis for which very general support has been found.

The new data on the dollar mark to be presented in this article fully support the conclusion reached in our previous articles,[7] from which we reproduce, by way of introduction, Fig. 1 taken from a copy of a letter written at New Orleans on September 12, 1778, by Oliver Pollock, "commercial agent of the United States at New Orleans," and sent to George Roger Clark, who was then heading an expedition for the capture of the Illinois country. The figure shows the close of this letter containing a financial summary, expressed in dollars. There are here five symbols written respectively to the left of the sums 1100, 5997, 328, 8550, 8613. Examining minutely the ones to the left of the first four sums, we find them to be p^s, made by a continuous motion of the pen, in this order: Down on the left, up on the right, the loop of the *p*, the *s* above. On the other hand, the symbol to the left of 8613 is made by two motions: One motion is down and up for *p*, the other motion is the curve for the *s*, one symbol being superposed upon the other. This last symbol is our modern dollar mark. According to the evidence supplied by the manuscript of Pollock's letter, our \$ is a modified p^s, the Mexican abbreviation for "pesos" or "piastres," or "pieces of eight." The chief modification consists in bringing the *s*, in p^s, down upon the *p*. In Mexican manuscripts going as far back as the sixteenth century the abbreviation p^s can be found. The practice of raising the last

[7] A full summary of the previous articles is found in F. Cajori, "History of Mathematical Notations," Vol. 2, 1929, pp. 15–29.

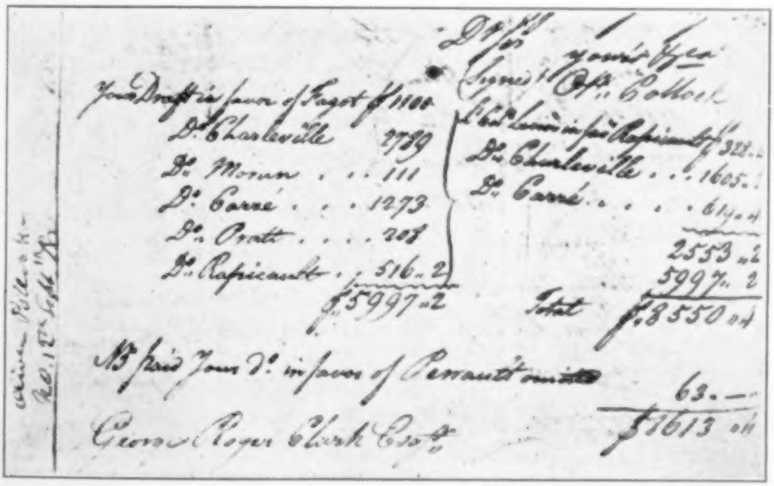


FIG. 1. THE ORIGIN OF THE DOLLAR MARK, AS SHOWN IN THE COPY OF A LETTER SENT BY OLIVER POLLOCK, FROM NEW ORLEANS, ON SEPTEMBER 12, 1778.

letter in abbreviations was almost universal among the Mexicans. Our dollar mark arose among those writers who were less addicted to the practice of raising terminal letters in abbreviations. If our views are correct, then the dollar mark might spring up in different places, quite independently, among various writers. And such was the case.

That the symbol in Pollock's letter was written in New Orleans is significant. The Gulf of Mexico and the Caribbean Sea constituted the American Mediterranean. Boats navigated the Mississippi River. On the Gulf coast and the West Indian islands people of different nationalities gathered, and commercial intercourse took place. These were the distributing centers for goods and also for coins. We quote from W. G. Sumner[8] certain phrases which show the connection between the American colonies and the West Indies. He tells of the trade Massachusetts had with the West Indies. He states that "scarcely had specie come into circulation in Massachusetts, when it was found that, although the remittance had been in silver, gold from the West Indies [then an inferior currency] began to stay in the colony"; trade of New York with "the West Indies" was about 1720 "wholly to the advantage of New York." "Coin was now coming freely [into New England] by trade with the West Indies." A similar statement is due to J. K. Upton:[9] "All the colonists were anxious to retain silver as a circulating medium and their trade with the West Indies brought considerable silver coin," but did not stay in the colonies because laws were enacted creating inferior legal tender. In the West Indies, the peso or Spanish dollar was in more general use than other coins, such as doubloons and joes. Westergaard[10] mentions also the rigsdaler, slettedaler, florin, ducat, livre and mark.

A proclamation[11] in Dutch, issued on February 22, 1760, at Fort Amsterdam in St. Martin, a West Indian island, forbids giving protection to Negroes from the island of St. Croix, on penalty of the sum mentioned in Fig. 2. The symbol

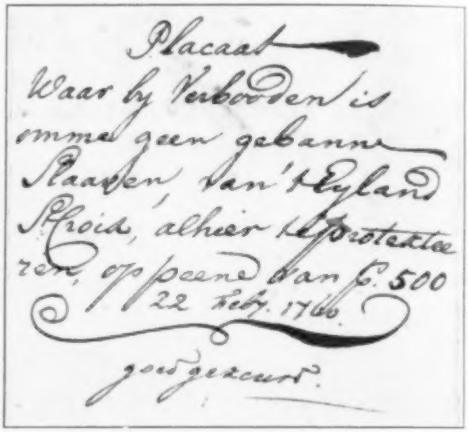

Placaat
Waar by Verboden is
ommen geen gebanne
Slaaven, van 't Eyland
St Croix, alhier te protectee
ren, op peene van P. 500
22 Feby. 1760.

FIG. 2. FROM A PROCLAMATION ISSUED AT THE WEST INDIAN ISLAND, ST. MARTIN, ON FEBRUARY 22, 1760, AND INDICATING A PENALTY OF, APPARENTLY, $500, FOR GIVING PROTECTION TO SLAVES FROM THE ISLAND OF ST. CROIX.

placed before the 500 may mean "piastres" ("pesos") or perhaps "guilders." The shape of the symbol suggests a p^s, rather than the letter G which does not call for the long downward or upward stroke on the extreme left. Another Dutch document, of the year 1790, writes out in full "piastres Gourdes" and indicates that this Haitian coin circulated among the Dutch. It is our interpretation that the symbol in Fig. 2 stands for "piastres." If this is correct, then we see in the document of 1760 a part-way descent of the letter *s* upon the letter *p* and, therefore, a step toward the formation of our dollar mark.

Positive evidence of a West Indian modern dollar mark is found in a record of the sale of Negro slaves in Porto

[8] William G. Sumner, "History of American Currency," 1876, pp. 8, 34, 40, 42.

[9] "Money in Politics," Boston, 1884, p. 7.

[10] W. Westergaard, "The Spanish West Indies under Company Rule (1671–1754)," New York, 1917, pp. 34, 92, 206, 225.

[11] Bancroft Library, University of California, Danish West Indian Collection.

Rico.[12] The early entries use the Mexican sign p^s for pesos, but a little before July 1, 1778, a new handwriting appears, containing several times the p^s, but six times also the double symbol p^s $, as in Fig. 3, which shows 1443 pesos and 2 reales. The doubling of the letters occurs for reales as well as for pesos. What does this sign signify? Simply the marking of the plural by repeating the letters, a practice which is prevalent to-day in the Spanish "E.E. U.U." to signify "Estados Unidos" and in the leans,[13] who was then interim governor of the colony.

There is a diary kept in the State of New York by Ezra l'Hommedieu in which, between August 1, 1776, and December 5, 1776, the dollar sign occurs fourteen times, at first with only one downward stroke, but the last three times with two downward strokes.[14] Mexican manuscripts indicate that sometimes the letter *p* in p^s was written with one stroke only, instead of the more usual downward stroke, followed by an

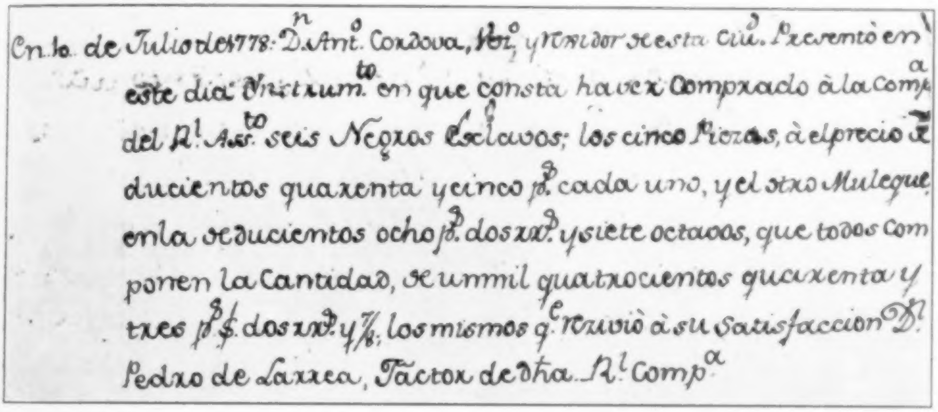

En 1o. de Julio de 1778: Dn. Antno. Cordova, Regor. y Prcdor. de esta Cdd. Presentò en este dia Instrumto. en que consta haver Comprado à la Compa. del Rl. Asto. seis Negros Esclavos; los cinco Piezas, à el precio de ducientos quarenta y cinco ps. cada uno, y el otro Muleque en la de ducientos ocho ps. dos rs. y siete octavos, que todos componen la Cantidad de unmil quatrocientos quarenta y tres ps $. dos rs. y 7/8; los mismos qe. recivió à su Satisfaccion Dn. Pedro de Larrea, Factor de dha. Rl. Compa.

FIG. 3. THE USE OF p^s AND $ SYNONYMOUSLY TO REPRESENT "DOLLARS," IN A MANUSCRIPT RECORDING THE SALE OF SLAVES AT PORTO RICO. THE DATE OF THIS SALE IS JULY 1, 1778.

English "pp." for "pages" and "LL.D." for "Doctor of Laws." This doubling is of prime importance in our problem of the origin of the dollar mark, for it clinches the argument with compelling force, that the $ descended from p^s. It is of interest to note that the earliest appearance of this symbol in the sale-record of slaves is April 1, 1778, a date only about five months earlier than the date of Pollock's letter. A later document, also written in the Spanish language, which contains the double symbol p^s $, was written on August 29, 1800, at S^n. Marcos de Apalache, in Florida, and addressed to the noted Marquis de Casa Calvo in New Orleans, upward stroke. The letter *s* written over the p with a single stroke would naturally give rise to the form $ of the dollar mark in place of the more usual $. L'Hommedieu was a member of the New York Provincial Assembly and recorded in his diary some of the financial transactions of the assembly. As a member of the Continental Congress he wrote, in 1800, a letter[15] containing the symbolism "$106 : 60."

In earlier articles[16] we have given facsimiles of dollar signs approaching the

12 Bancroft Library, 1768–1779, Porto Rico. Real Compania del asiento de Negros.

13 Bancroft Library. Louisiana Papers. Letter of Petro Olivier.

14 For drawing of symbols, see F. Cajori, *op. cit.*, Vol. 2, p. 25.

15 Library of the Historical Society of Pennsylvania, Dreer Collection.

16 F. Cajori, *op. cit.*, Vol. 2, p. 22.

modern forms, occurring in letters written in New Orleans (1783 and 1786), on the Mississippi (1787), in Philadelphia (1792), in Nouvelle Madrid, Mo. (1793 and 1794), in New Orleans and Philadelphia (?) in 1796, at Louisville (?) in 1799. The modern sign occurs frequently in a ledger kept by George Washington, now preserved in the Omaha Public Library. The earliest date in the ledger is January 1, 1799. The sign appears also in a letter of September 29, 1802, now kept in the Harper Memorial Library of the University of Chicago. It is written by William A. Washington and relates to land above the Potomac belonging to the estate of George Washington.

What has been regarded as the earliest appearance of the dollar mark in print is in Chauncey Lee's "American Accomptant," published at Lansingburgh, New York, in 1797. But Lee's sign for "dimes" is more nearly our modern dollar mark than Lee's sign for "dollars."[17] The modern dollar mark occurs in the arithmetics of Daniel Adams (1807), an anonymous author (1811), Samuel Webber (1812), Jacob Willetts (1817).[18] We have seen the dollar mark in the *Boston Patriot* of September 1, 1810. Ernest Horn, of Iowa City, informs us that "The Epistolary Guide" of James Hardy, published at New York in 1817, gives the $ in all models of letters referring to amounts expressed in dollars. The Mexicans, at the time they achieved their independence from Spain (1821), were not yet using the $ in print. In a Mexican book of 1834 on statistics,[19] both the ps and $ are used. Our $ was introduced into Hawaii by American missionaries in a translation of Warren Colburn's "Mental Arithmetic"[20] in 1835.

The Spanish-Americans placed their p^s after the numerals, as in 65 p^s, while the English colonists, being accustomed to write £ before the number of pounds, usually wrote the $ to the left of the numerals, thus $65. It is placed after the numerals in some letters written by Joseph Montfort Street[21] in Prairie de Chien, Wisconsin, and in Rock Island, Illinois, in 1832 and 1836. It is placed sometimes before and at other times after the numerals, in letters and account books of the English trader William Petty Hartnell,[22] of California, and of John Begg at Lima, Peru, who was in trade relations with Hartnell in 1820 and later. In fact, in a letter of May 15, 1825, signed by McCullogh, Hartnell and Company, one finds "17727." In the newspaper *La Prensa* of 1910, in Buenos Aires, the $ frequently follows the numeral in the short advertisements, but precedes the numerals when arranged in columns.

Our conclusion is that the modern dollar mark is a modification of the Mexican sign p^s for pesos or piastres, the chief alteration being the lowering of the letter *s* upon the letter *p*. As the result of extensive and careful empirical study, this conclusion is now as firmly established as is the origin of any other monetary symbol, and more securely fixed than is the origin of any mathematical symbol which is not the conscious invention of some known individual. Nevertheless, from the examination of more manuscripts, much additional detail may be gathered on the spreading of the dollar mark in the United States and the American continent.

17 For facsimile of Lee's symbols, see F. Cajori, *op. cit.*, Vol. 2, p. 27.

18 For exact references, see F. Cajori, *op. cit.*, p. 28.

19 J. A. Escudero, "Noticias estadisticas del estado Chihuahua," Mexico, 1834.

20 Copy of translation in the Newberry Library, Chicago.

21 Iowa State Historical Department. Letters of Joseph Montfort Street.

22 Bancroft Library. Hartnell letters and account books.

JOHANNES EVANGELISTA PURKINJE
(1787-1869)

By Dr. VICTOR ROBINSON

EDITOR OF "MEDICAL LIFE," NEW YORK

To tarry at a discovery to its complete exhaustion, a discovery which casts a glamour about other names, was not Purkinje's habit. Driven from one discovery to another, he leaves the details to others; his works are stimulating data for further research. In addition, there are two rare qualities in this exalted spirit: respect for the youngest of talents, and modesty in not speaking of himself: both of these go with his noble character, but they are also to blame for Purkinje's achievements not being honored as they should be.

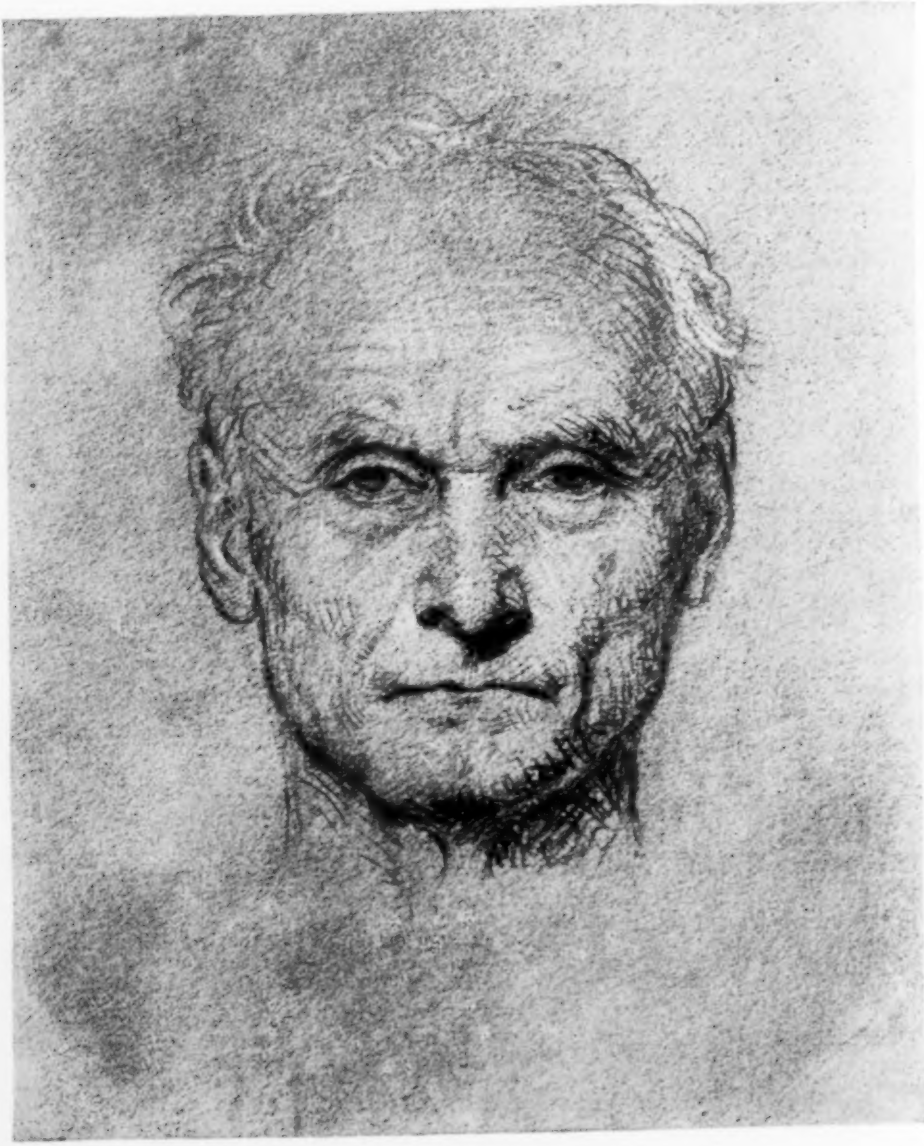
—*Th. Eiselt, 1859*

THE village of Libochowitz is not on the average map, but it lies near Leitmeritz on the Elbe, a town situated amid such natural beauty that it is known as the Bohemian Paradise. Man has ever done his utmost to despoil all earthly paradise, and during that terrible period which history calls the Thirty Years' War—when a whole generation of humanity shed its blood over myths—most of the families that still remained above ground departed from this region.

The call of the soil is strong, and though the plow turn up bullet and skull, corn grows well on land that has been watered with blood. The healing years passed over Libochowitz, and the fields of Baron Herberstein were under the care of Agricultural Official Purkinje. His family must have occupied quarters in the baronial home, for here his wife, Rosalie Safranek, gave birth to her son Jan on December 17, 1787. Thus Johannes Evangelista Purkinje came into the world in the castle of Libochowitz, and not in a "peasant's hut," as is stated by R. Burton-Opitz and others. For purposes of biography, it is more interesting to be cradled in a peasant's cottage than in a nobleman's palace, but history is inexorable.

The young Purkinje attended school in his native village, and took lessons in music and singing, in accordance with the Czech fashion of those days. His voice paved the way for his further education, and he was sent as a chorister to the Piarists in Moravia, where he devoted himself to philology. He graduated from the normal school in Mikulov, and then completed the course in the gymnasium. When it became necessary to select a profession, Purkinje found that he had grown accustomed to the Piarists and was attracted to pedagogy, and for these reasons entered the Order of the Piarists as a teacher of ancient languages. His novitiate year was spent in Stará Voda near the Silesian border, whence he was transferred to Stražnic; after 1806 he proceeded to Litomyšl—all little towns which mean nothing to the reader unless he be Czech. The peace of monastic teaching must have appealed to him in many ways, yet he did not take the vow, and Fichte lured him from the monastery to the university. He had already learned French and Italian—later supplemented by various other modern tongues—and had read widely.

He bade farewell to the Piarists, and came to his country's capital to study philosophy. At Prague he occupied himself also with literature, and for a time thought of becoming a man of letters. He was as frugal as David Hume, and the meager fees he received by tutoring enabled him to live, for in those days scholars possessed the secret of subsisting on ideals. His chief pupils were the young barons, Schutterstein and Ferdinand Hildeprandt; Purkinje



PURKINJE
By Joseph Mánes

looked forward with keen pleasure to accompanying the latter to the Stavnic Mining Academy in Slovenia, but his dream was shattered when Hildeprandt joined the allies in the campaign against Napoleon.

Well-educated but still without a profession, Purkinje now decided upon medicine. It was never his intention to become a practicing physician, but he felt that the medical sciences would give him an insight into nature. Even toward the conclusion of his medical studies, the pedagogue's mantle clung to him, and he thought of asking the aid of the Hildeprandt family to establish a special teaching institution of the natural sciences, and he contemplated a visit to Switzerland to acquaint himself with the methods of Pestalozzi and his disciples. In 1818 he acted as assistant in anatomy and physiology under Rottenberg and Ilg, and in 1819 graduated with a dissertation on the subjective aspects of vision. He was already thirty-two years old, an age at which many famous scientific careers have closed.

The year 1819 was a troubled one for German students. August von Kotzebue, not content with his popularity as a playwright, had returned from Russia to his fatherland in the capacity of the czar's spy. Establishing a weekly newspaper, he ridiculed the students for their national aspirations, and especially mocked their efforts to secure free institutions. A clever man, the columns of his journal were funny and cruel, but a certain theological student had no sense of humor and killed him. The dagger of Karl Sand gave Metternich his opportunity to muzzle all Germany. Freedom of speech and press were abolished by the Carlsbad Decrees, students were condemned to death for wearing a ribbon, private papers in private houses were searched without warrant, journalists went into hiding, the naturalist Oken fled to Switzerland, professors and pupils emigrated to America and privy councillor Wilhelm von Humboldt, throwing down his portfolio in despair, relinquished politics forever to devote himself to the mysteries of the Basque tongue and the old Kawi language of Java. Wise Wilhelm von Humboldt! It is always a relief to turn from the world to the cloisters of culture.

In this year the bitter genius of Schopenhauer gave to the German people his masterpiece, but they were in no condition to read the "World as Will and Idea." They paid more attention to a pamphlet written by Hartwig Hundt, later suppressed by the censorship, in which the novelist made the suggestion, "As for the children of Israel, let them be sold to the English who could employ them on their Indian plantations instead of the blacks. In order that the tribe may not increase, let the men be emasculated, and their wives and daughters lodged in the houses of shame." In times of reaction, all sorts of ideas come to people's heads. Through the turmoil and general consternation, one man remained Jove-like, aloof, serene, going forward with his love affairs and work: Goethe, unperturbed by Napoleon, was unaware of Metternich. Among innumerable other activities, carrying on his researches in colors, Goethe read Purkinje's thesis with admiration, admitted that it stimulated him greatly, and quoted it frequently. The Bohemian physiologist, like the rest of the world, came to the oracle at Weimar, and Goethe was astonished at his personality and devotion to science. "Such an autodidactic and self-tormenting, talented Piarist," said Goethe, "represents a strange contrast in the midst of the Protestants." It was inevitable that among Goethe's crowded laurels should be entwined this leaf:

> I have taken the liberty of dedicating to you the second edition of my researches on "Sight from the Subjective View-point," since I could not resist making my strenuous mental efforts a memorial of my sentiments. Let us disregard

PURKINJE
OIL PAINTING BY PETER MAIXNER

the fact that the work has been reprinted at the same time in a medical journal; this was not according to the original intention, and is a tribute which my poverty has been compelled to pay to booksellers as the manuscript wandered around hopelessly for a year. I hope this little volume will stir up a little more the phlegmatic interest of the Germans.

I wish to draw Your Excellency's attention to the appearance of the color-spectrums which could also be exploited in the field of applied art, inasmuch as according to the personal observations of Wach, the Berlin painter, the shady parts in colored drapery yield a clear dark color only when they obtain a light covering of contrasting hue, when the objective produced by the subjective which has been created by the illuminative parts are eliminated.

I am also sending you a specimen of my researches in the development of the bird's egg before laying.

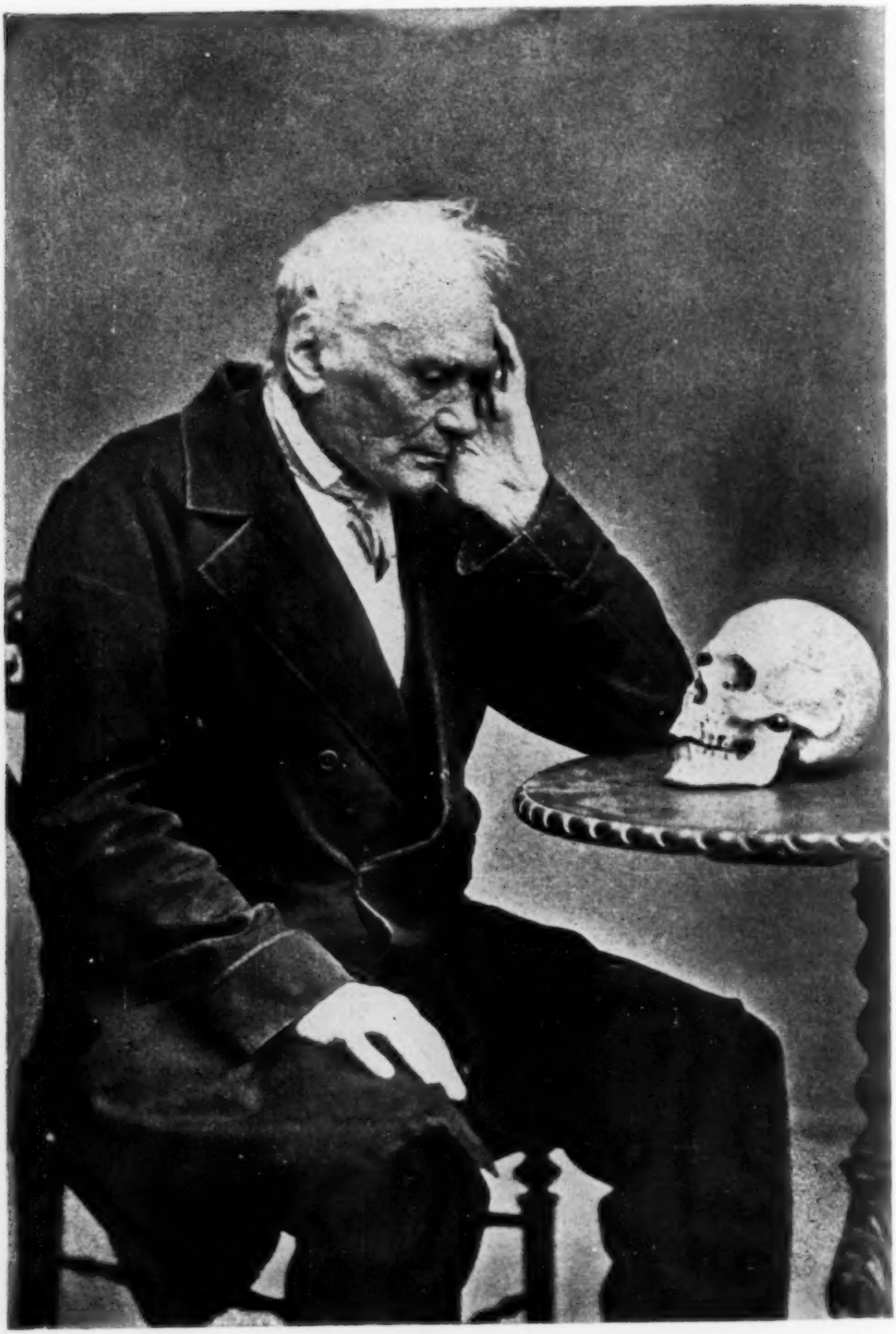
May you enjoy, with God's help, yet for a long time, your life so precious to us all.

J. Ev. Purkinje

While serving as house-tutor in Blatná in the family of Baron Hildeprandt, Purkinje had met the Baroness Adelaide Desfours. In those days literature was potent to move men and women, and after reading Schultze's poem, "Enchanted Rose," Adelaide confessed that "she felt in her heart the magic spell and her life blossomed out into full bloom." She found herself overwhelmed with love for the gifted tutor, but an aristocratic lady must be discreet, and love was translated into friendship. Twenty-two of her letters, written to Purkinje after his graduation, remain as evidence of this stifled passion: in the last of her correspondence, she tells him of her mother's death, reproaches him with not having answered her former letter, and while informing him that she has rejected a proposal, advises him to marry. Purkinje remained silent, but he did not forget, and in later years published Kacer's version of "Enchanted Rose."

Before this edition appeared, Ernst Daniel August Bartels, probably the first professor of physiology in Germany, was called from Breslau back to the older university of Marburg where he had previously taught. Purkinje was among the candidates for the vacant chair, and was rejected by the professors who did not look with favor upon the unknown Slav. They did not reckon, however, with two great European powers who stood behind Purkinje, and since the combination of Goethe and Alexander von Humboldt was irresistible, Purkinje in 1823 went to Breslau in spite of the faculty. He found himself an unwelcome guest of the university, and his chair was not lined with velvet. Naturally he spoke German with a tinge of Czech accent, and the anatomist Otto sarcastically informed him that if he wished to be understood, he would better lecture in Latin. Purkinje was not eloquent in expounding theories, and when he hinted that up to the present a lecturer in physiology was "merely a mechanism by means of which the theories of the old masters were repeated again and again," his classes dwindled in indignation and the faculty circulated a petition for his removal.

Later Purkinje stirred up more trouble by asking for a microscope. The authorities could not understand why a physiologist needed a microscope, and they sighed for the good old days of Bartels. There was the famous Bartels, becoming a Geheimrat and climbing to the Berlin chair; writing many books on *Naturphilosophie*, medicine and theology; diagnosing all diseases with the most learned phrases and knowing enough to denounce such new-fangled notions as Laennec's stethoscope; and yet he never needed a microscope. If this were permitted to go on, the university would be cluttered up with apparatus and specimens, and the students would be occupied in performing experiments instead of reading van Helmont and Haller and Bartels. Evidently the arguments failed to convince Purkinje, for in an unoccupied corner of the college building he



PURKINJE
A CONTEMPORARY PHOTOGRAPH

opened the first physiological laboratory. Had John Hunter tried to install his museum in St. George's Hospital, he would not have aroused more opposition than Purkinje with his laboratory, which seemed to his colleagues utterly useless in medicine. Moreover, Otto, officious and esthetic, objected strongly to the stench. Purkinje solved the difficulty by transferring the laboratory to his own house, and thereafter he lived and dined and slept in the midst of physiological equipment—including the unavoidable odors. His wife was not supposed to complain, since she was the daughter of the scientist Rudolphi.

In estimating the place of Purkinje in science, it should be remembered that he antedated the great experimental physiologists whose names are so familiar to-day. When Purkinje published his thesis in 1819, Johannes Müller was just entering the University of Bonn, Claude Bernard was a child of six, Brown-Séquard and Carl Ludwig were infants, Du Bois-Reymond was celebrating his first birthday, Brücke was uttering his first cry and Helmholtz and Huxley were yet unborn.

The test of a scientist's character is his relationship to obscurer workers. Marshall Hall, in announcing the existence of a system of excito-secretory nerves, did not mention Henry Fraser Campbell, for he had never heard of the American. Dr. Campbell, insisting that he had anticipated Marshall Hall and Claude Bernard in this discovery, forwarded to the English investigator a long letter and abstracts of his publications. The great Marshall Hall, then in his last illness, could easily have been too occupied to concern himself with the claims of the Georgia physiologist, and Campbell would have been forgotten. Instead, he sent a communication to the *Lancet*, giving the young doctor such full and generous credit that Campbell was encouraged to collect his essays into a volume which he dedicated to Marshall Hall "in high admiration of his genius, and in heartfelt acknowledgment of his liberality." This idyll of physiology is rare enough, while contests over priority are frequent, wordy, often vindictive and seldom settled. Instances in which teachers appropriate the labors of their pupils with inadequate recognition are not unknown even at the present day.

In this respect, Purkinje was particularly chivalrous and free-handed: he frequently incorporated his most important researches into dissertations which were signed by his students. Of course it was Carl Ludwig who developed this habit into a fine art. When Martin Barry, notable as the first to observe the union of the spermatozoon with the ovum, worked with Purkinje and showed him his essay on fiber, Purkinje translated it for him and had it published in Müller's *Archiv*. Another pupil was Gabriel Valentin, who increased our knowledge of taste and touch, of nucleus and nucleolus, and whose "Manual of the Development of the Fetus" was the first systematic treatise on embryology—a mighty worker was Valentin in his day, ranging various fields, but his name has been almost submerged under the never-ceasing output of his successors. It was not the fate of Purkinje to leave behind him a school like Johannes Müller or Carl Ludwig, but we may say of him as Helmholtz said of Müller: "Whoever comes into contact with men of the first rank has an altered scale of value in life. Such intellectual contact is the most interesting event that life can offer."

Purkinje could have made his discoveries in a hayloft, yet academic life must have had its attractions, for he retained his chair for over a quarter of a century. His work was the most important produced in the Silesian university until the advent of Ferdinand Cohn, who after building the foundations of bacteriology at Breslau, helped Robert Koch lay the corner-stone there by his demonstration of the life-history of an-

thrax: Cohn wrote the great news to Darwin, and the old biologist replied, "I well remember saying to myself, between twenty and thirty years ago, that if ever the origin of any infectious disease could be proved, it would be the greatest triumph to science; and now I rejoice to have seen the triumph."

Gradually the personal character and exceptional attainments of Purkinje gained recognition at Breslau. Students came to his classes and laboratory, his colleagues acknowledged his services, his small salary was increased to more respectable proportions, much-desired apparatus was secured and in time the Prussian government erected for him a separate building devoted exclusively to physiology—this first Physiological Institute was opened on November 8, 1839, and forty years passed before Berlin followed Breslau. Purkinje had reached his goal, but the fire of his genius had exhausted itself, and most of his great discoveries, the mere list of which still amazes us, had already been made in his own home. He admitted that "many promising investigations await the time when I shall have regained my lost love of work," but the fallow years proved that the ardor of youth had gone. He was indeed pleased at the tribute to his labors and science, although he no longer had the strength or enthusiasm to nauseate and sicken himself with huge doses of digitalis in order to study disturbances of vision. Moreover, administrative duties and requisitions for supplies are incompatible with research. It is pleasant to be a director or a dean, but who ever heard of a dean discovering anything? Purkinje now neglected his hard-earned compound microscope to translate the lyrics of Schiller into Czech.

The following letter written by Purkinje during his latter years at Breslau exhibits his interest in his seventeenth century countryman, the great schoolmaster whose theological performances were unfortunate, but whose name will always survive in the history of education as one of the first rationalists in pedagogy. We are indebted for this letter to the courtesy of Purkinje's grandson, Dr. Cyril Purkyně, director of the Státní Gelogický Ústav Československé Republiky:

Breslau, August 29th, 1844.

My dear friend:

That I am with you in spirit, although far away for the past two years, you may judge from my effort to join you and share with your vicissitudes until death. With the assistance of Mr. P. H. Klebelsberk I have obtained Austrian citizenship for which I applied last year, and this year I have presented through this same gentleman my request for the chair of physiology at the University Praha, to Count Kolowrat. I doubt whether it would be advisable to inform Mr. Nádherný regarding this step, as he seems to shun my free thinking, although he himself has recently suggested to me to apply for transfer. My petition for citizenship has been presented upon his advice, and perhaps without need. His second suggestion was to send a petition to the Emperor, although my citizenship definitely includes my right (for which I have asked) to apply for appointments to the institutes of learning in Austria. I presented myself to Türkheim and later upon the advice of K. to Kolowrat. We shall see what the result will be. From the enclosed letter of the Rev. Sidewice, Lésno, Prussia, you will note that I have reopened negotiations for the purchase of the manuscript of Comenius and that they now seem to be more approachable, perhaps because of the fact that the Gymnasium Director, Mr. Scholer, who was the one who chiefly insisted to retain and exhibit the manuscript together with the relic and portrait of Comenius in the gymnasium library, has now been transferred to Erfurt. I do not see from your letter that Čelakovský could have given you any information about it, as you certainly would not have been silent on the subject and thus frustrated my many years' effort.

I would have replied to your letter earlier, but I did not want to come to you emptyhanded and so I copied for you from Comenius' own manuscript, rewritten and reedited church songs, introduction, which might be published in the Musejnik as an example of writing of that time.

Should the Museum Committee definitely not wish these manuscripts, please have them send

me a few lines in German for my verification. You will kindly return to me Sidewice's letter.

I look forward to an early response from you and with my respectful greetings to your wife and kisses to your children, I am,

Your devoted
JAN PURKYNĚ

As previously stated, Purkinje's first work was in physiological optics. Thrice he wrote his name in this field: Purkinje's figures, Purkinje's images and Purkinje's phenomenon. A bibliography of the contributions to these subjects during a century would show how a large number of investigators received their impulse from Purkinje. The work of Purkinje was germinative, for even if it consisted of only a few paragraphs, it proved reproductive. His method of lighting the retina, his measurements of the curvatures of the lens and cornea, his studies of the refracting surfaces of the eye with mirrors not only anticipated the ophthalmoscope of Helmholtz, but even made it inevitable.

The name of Francis Galton is usually associated with the foundation of fingerprint identification, but seventy years earlier, Purkinje wrote: "The wonderful arrangement and design which are on the palm of the hand and upon the sole of the foot, and especially the little hollows on the fingertips, the papillary lines, command our attention." He then proceeded to describe with accuracy the unchanging character of fingerprints, illustrated with various figurations. His pioneer work is of value to all criminologists, and the English penitentiary inspector, Major Arthur Griffiths, author of the "Chronicles of Newgate," writes: "The permanent character of the finger-print was first put forward scientifically in 1823 by J. E. Purkinje, an eminent professor of physiology, who read a paper before the University of Breslau, adducing nine standard types of impressions and advocating a system of classification which attracted no great attention." With G. Rosche, we may call Purkinje the old master of dactyloscopy.

Most pre-Virchovian workers, including Purkinje, are rather roughly handled in the "Cellular Pathology," but Virchow credits Purkinje with having devised the term *corpora amylacea;* he also introduced the terms *enchyma, cambium, protoplasm* and others—almost reminding us of Walther Flemming who in a single year increased the nomenclature of cytology with *mitosis, amitosis, karyomitosis, dyaster, karenchyma, net-knot, spireme, mitome, karyoplasm* and *interfilar substance.* Richard Mead, relying on the experiments of Galen, felt safe in swallowing the poison of vipers, but Purkinje broke new ground in some of his self-experiments with belladonna, camphor, digitalis, opium, stramonium and turpentine.

Every investigator of the first rank has conducted a host of minor researches, and among Purkinje's innumerable ones may be mentioned: an early paper "On the World of Dreams," now over a century old, which should be read to-day in the light of Freudism; the contribution to acoustics, "On Tartini's Tones"; his auscultation experiment, by which he was able to determine the points of rest and motion of a vibrating plate, without employing Chladni's sand; his work on rhizopods, the nautilus, and embryology of the tadpole; his original description of the peculiar formation of the skin of cucumber plants, and his observations of the methods of fertilization in the plant world.

More important investigations, and belonging chiefly, but not exclusively, to his first sixteen years at Breslau, were his contribution to photometry; his observation that deaf-mutes can hear through the bones of the skull; his experiments upon the production of vertigo which paved the way for the knowledge of nystagmus; his work with Pappenheim on artificial digestion which antedates Schwann, including the demonstra-

tion of the dissolving power of acidulated infusion of pancreatic juice; his researches with Valentin on ciliary epithelial movement and the explanation of its independence of the nervous system; his original description of bone, cartilage, blood-vessels, gastric glands and special organs; his discovery of the sudoriferous glands and their ducts; of the flask-shaped Purkinjean nerve-cells with their axones and branching dendrites which form the characteristic features of the cerebellum, and of the Purkinje fibers in the cardiac muscle. In microscopy he was the first to use the microtome, microphotography, Drummond lime light, glacial acetic acid, potassium bichromate and Canada balsam.

There is much confusion in regard to discoveries of the nucleus: standard general and medical dictionaries give incorrect information, and Locy, although he devotes much space to it, in no way clarifies the subject. We have frequently read the statement that Purkinje in 1825 discovered the nucleus of the human ovum; this is manifestly impossible when we remember that the mammalian ovum itself was not discovered until two years later by von Baer. What Purkinje did discover was the nucleus or germinal vesicle in birds, announcing his find in the *Gratulationschrift* to Blumenbach; he was likewise the first to use the term *protoplasm* for the embryonic formative substance. Misstatements concerning Purkinje are prevalent: for example, Littré, in his classic Dictionnaire de Medecine, actually refers to him as *anatomiste hongrosis;* while Dorland, after thirteen editions of his popular dictionary, repeats this error, and gives the date of his death as 1850! A man whose connection with the cell doctrine was as intimate as Purkinje's deserves more accuracy on the part of lexicographers. If Schleiden and Schwann are the fathers of the cell-theory, Purkinje is at least its great uncle, for prior to Schleiden and Schwann he taught that organs consist of cells and nuclei, and suggested the probable identity in the structure of animal and plant cells. In this, however, he was not without various forerunners.

Since the universal cell is now recognized as the basis of life, we should be familiar with a chronology of cytology, and many of the earlier dates and facts will be found in that storehouse of biological knowledge, Johannes Müller's book. It is a pity that this great manual of physiology should have been superseded by later productions, for in numerous respects it has never been equaled. Even to-day, with a little editing and some foot-notes, it would serve admirably, for as far as we recall, the only passage that is entirely obsolete is the following: "Woman is distinguished by her modesty, meekness, patience and amiability; by her readiness to sacrifice her own good and herself for the sake of others; by her tenderness, sympathizing disposition, and piety. The field of her activity is her home and family."

If it be asked why Purkinje spent twenty-six years in a foreign country, the answer is simple: for the same reason that Kaspar Wolff, the founder of modern embryology, journeyed from his native Berlin to spend his last thirty years in Russia. Purkinje had applied for a chair in Prague, but they were filled with long-lived occupants, or the authorities appointed what Huxley would call a "safe nobody." Wolff may have grown accustomed to Catherine the Great, but in spite of his success at Breslau, Purkinje felt an expatriate, and cast many longing glances toward his own soil—more than once he sought an opportunity for returning, but Bohemia was not yet ready for her greatest son. Purkinje was a true Czech, and Tyl's "Kde domov můj" stirred him as if he were a gymnasium

student. Fortunately for his reputation, he was not guilty of the extravagances of the great Swedish anatomist, Olof Rudbeck, who, ignoring his real discoveries, regarded the "Atlantican" as his chief work—huge folios claiming that after Noah's flood, the land which Japheth sought and found was Sweden, the Almighty's favorite spot on earth. How men of intelligence can do these things is really beyond comprehension.

Purkinje finally returned to Prague as professor of physiology. "Well do we remember," says a Czech writer, "how Purkyně's coming in 1850 was celebrated not only in Prague, but in all the provinces." Old and famous, he was no longer compelled to fight for a laboratory: the Austrian government gave him a splendid one, with a capable assistant and an adequate salary. Purkinje was over sixty, and he proved that apparatus alone can not make discoveries.

It would be entirely erroneous, however, to believe that he had retired, or that his intellectual activity was at an end. The days of his epochal discoveries were indeed over, but he had made enough for an entire institute of research. He now busied himself with Czech politics, and whoever did that in the mid-nineteenth century was much occupied—he was elected to the senate and served with exemplary diligence. The pen is often the staff of age, and Purkinje wrote copiously; he was a founder and editor of the journal of natural history, *Ziva,* and for several years one of its principal contributors. He vitalized the *Journal* of the Bohemian Museum, and his popular essays in the Bohemian language stimulated interest in nature. He continued to develop the ideas of Pestalozzi, and discussed the establishment of orphan asylums from a scientific standpoint. Josef Klika was able to produce a lengthy monograph devoted exclusively to "Purkinje as a Pedagogue."

There are few scientific workers of the scope of Purkinje of whom as little is generally known. His name does not once occur in Baas, although that thick and valuable volume is at times overloaded with forgotten names. If an explanation is sought of this and similar omissions elsewhere, it is found partially in the fact that Purkinje, by returning to Prague and not identifying himself with the Vienna school, stood apart from the main stream of German medicine—indirect but potent testimony of the influence of the Vienna school. Distinguished medical travelers, such as Richard Bright and those who followed in his footsteps, have left their impressions of medical Vienna, but Prague was out of the way.

It would not be correct, however, to cite Purkinje as an example of genius overlooked by his contemporaries and neglected by posterity. Even when he ceased to keep up with the progress of physiology, and younger giants overstepped his own frontiers, he was not disregarded. In fact, to read nice things about himself he was not obliged to follow the usual custom and wait for the obituary notices. In 1859, the distinguished Eiselet published an accurate analysis of Purkinje's work, occupying twenty printed pages; in 1867, an appreciative biographical sketch appeared in *Světozor,* concluding with the passage:

> . . . the greatest reward and one which is dearest to him is the unbounded affection with which our entire nation clings to him, the proof of which was apparent last summer when he passed through some parts of the land. Wherever he appeared citizens endeavored to honor him; the day of his coming was a day of celebration. He is truly not only honor-deserving, but a really lovable personage. Whoever sees him must love him. He has lived eighty years, and certainly not in leisure, but he still walks with vigor and enjoys splendid health; it seems as though nature herself wishes to mark her ardent admirer and worker.
>
> His faculties are excellent, and he who would count upon his "aged memory," would be much surprised. His humor retains its original fresh-

ness; he likes to be in company and contributes to conversation his characteristic wit. He has never known idleness and despises it now: he must be active, always, either in his own branch, or he finds other work and pursues it with youthful enthusiasm. Only recently he translated the "Evangelium" of Sallet, and Barthriari's "Book of Love"; he edited the original Austria Polyglotta, and learned the difficult Magyar tongue: he practices his violin, etc.

We can not do better in taking leave of this noble and beloved son of our nation than to call heartily *Mnogaja leta!* [many years].

In 1868, the Bohemian Medical Society at Prague published a quarto—*Quod bonum, felix, faustum fortunatumque sit, Joanni Ev. Purkyně, diem semisaecularem X. dec. 1868 summorum in medicina honorum in alma antiquissimaque universitate Pragena celebranti gratulatur. . . .* The obituary notice in the *Proceedings* of the Royal Society of London, after summing up his unusual achievements, states:

In 1848 he attended the meeting of the Slavonic races in Prague, and was present at the celebration of the five hundredth anniversary of the foundation of the university, when the degree of doctor of philosophy was conferred upon him. A long-cherished wish to be enabled to pass the remainder of his days in his native country was gratified. . . . His election as a foreign member of the Royal Society took place in 1850. He was corresponding member of the French Institute, member of the academies of Vienna, Berlin and St. Petersburg and of many other learned societies. He retained his vigor of body and mind up to the last days of his life. His death, after an illness of no long duration, on the 28th day of July, 1869, was mourned by every class of society in Bohemia.

When we think of that trinity of astronomers, Horrocks, Gascoigne, Crabtree: Jeremiah Horrocks, discovering the transit of Venus across the sun, and in terror that his Sabbath duties as a parish curate would prevent him from observing this phenomenon, practically a beggar, without leisure for science, in broken health, dead at the beginning of his twenties, and from his grave teaching a Newton; his friend, William Gascoigne, inventor of the micrometer, slain in his youth at Marston Moor, leaving his work unfinished; his other friend, William Crabtree, corrector of the Rudolphine Tables, likewise disappearing early from the banquet of life in an unknown manner—we are thankful that Purkinje, like Goethe and Humboldt, was spared by fate to write *Finis* to his labors. At the time of his death, Purkinje was in his eighty-second year. Happy is the pioneer who becomes a patriarch, and at whose bier a grateful and sorrowing nation bows its head.

Now that Purkinje's beloved Bohemia has emerged as an independent country, the Republic of Czechoslovakia is adding new laurels to the name of Purkinje. Kamil Lhoták v. Lhota, professor of pharmacology at Prague, edited a handsome volume of Purkinje's original monographs. Paul J. Hanzlik, of Stanford University, informs us of the sad fact that Dr. Lhoták died young of gastric carcinoma, but no doubt other devoted hands will carry on the work. Professor Hanzlik has also directed our attention to two volumes recently issued by the Czech Medical Society of the personal correspondence of Purkinje, containing letters sent to him from a considerable number of people in all walks of life and from all over Europe—the nobility, statesmen, publicists, poets and scientists.

Foreign countries have also not forgotten him. E. Thomsen, of the University of Copenhagen, published in the *Skandinavisches Archiv für Physiologie* a study of Purkinje for which he received a gold medal. In a personal letter to Henry Jerry John, of the Cleveland Clinic, Dr. Thomsen writes: "There does not exist any reprint of my article on Purkinje. That work was written when I was a poor student, unable to buy reprints!"—here, then, is an important function for the photostat. Dr. John is the chief Purkinje student in

this country, and after several years of effort has collected, in many volumes, practically everything that has been written by and about his illustrious countryman. We can not permit this occasion to pass without acknowledging our indebtedness to Dr. John for placing at our disposal his patiently accumulated data and the illustrations which adorn his essay; when we add that Dr. John himself is planning a biography of Purkinje, yet readily granted prior use of his material, his generosity will be realized. A definitive biography of Purkinje, sixty years after his death, is much desired, for his influence lives: the *Quarterly Cumulative Index Medicus* for 1928 seems to contain more references to Purkinje and his work than to any other physiologist of his era. It is the glory of Purkinje that he holds a foremost place among the investigators who found physiology a speculative subject and left it an experimental science.

Hradčany Hill with its castles and cathedrals has seen a thousand years of battle, and for centuries the waters of Vltava have been reddened by intolerance. Towers upon towers, and those black Towers of the Abandoned. This is the story of Prague, and it is also the story of every capital in Europe. Climbing the Petřin, looking over Prague to the Giant Mountains, and from the heights of Moravia's frontier to the Bohemian Forest, how magnificent would be the view if we did not know that every inch of soil was bloodstained. Prague is beautiful—Humboldt calls it the most beautiful inland town of Europe—and to enter this historic threshold would be a feast for the soul, could we but forget the aggressions of kings and the endless strife of conflicting sects in the name of the Prince of Peace. . . . That wonderful old clock with the moving apostles and the crowing cock is still ticking the time—the clock that told the hours before Columbus set sail for America and immortality. Those countless moss-grown tombs in the ancient and crowded burial-ground of the Jews—under the elder-trees, the teacher tenderly surrounded by his thirty-three scholars. To Prague in his broken years came that master of the moon, Tycho Brahe, and here are his remains and relics; after him followed a pock-marked vagabond from a public-house to capture a planet for a mad emperor—John Kepler's "Commentaries on Mars" helped fulfil the prophecy of Libussa: "I see a city whose glory touches the stars." Monuments of monarchs and warriors—several recently removed from the public squares and hidden in museums. Let these medieval spirits disappear forever, until there glows across humanity's sky the sunrise that shall never set, burning away the barriers that divide the human race, revealing at last to the children of Mother Earth that none can be aliens and all are brothers. . . . Wandering through the streets of Prague, in the aimless yet interested fashion of tourists, we came suddenly upon a simple house with a plain tablet stating that this was the house of Purkinje. To the student of science this is the most inspiring spot in all Prague, for here lived the man who standing humbly before truth, read many of nature's secrets, and thus enlarged the human horizon.

SPACE, TIME AND EINSTEIN[1]

By Dr. PAUL R. HEYL

U. S. BUREAU OF STANDARDS

Whether we understand it or not, we have all heard of the Einstein theory, and failure to understand it does not seem incompatible with the holding of opinions on the subject, sometimes of a militant and antagonistic character.

Twenty-four years have elapsed since Einstein published his first paper on relativity, dealing principally with certain relations between mechanics and optics. Since that time a new generation has grown up to whom pre-Einstein science is a matter of history, not of experience. Eleven years after his first paper Einstein published a second, in which he broadened and extended the theory laid down in the first so as to include gravitation. And now again, thirteen years later, in a third paper, Einstein has broadened his theory still farther so as to include the phenomena of electricity and magnetism.

In view of the rekindling of interest in Einstein because of the appearance of his latest paper it may be worth while to reexamine and restate the primary foundations upon which his theory rests.

The general interest taken in this subject is frequently a matter of wonder to those of us who must give it attention professionally, for there are in modern physical science other doctrines which run closely second to that of Einstein in strangeness and novelty, yet none of these seems to have taken any particular hold on popular imagination.

Perhaps the reason for this is that these theories deal with ideas which are remote from ordinary life, while Einstein lays iconoclastic hands on two concepts about which every intelligent person believes that he really knows something—space and time.

Space and time have been regarded "always, everywhere and by all," as independent concepts, sharply distinguishable from one another, with no correlation between them. Space is fixed, though we may move about in it at will, forward or backward, up or down; and wherever we go our experience is that the properties of space are everywhere the same, and are unaltered whether we are moving or stationary. Time, on the other hand, is essentially a moving proposition, and we must perforce move with it. Except in memory, we can not go back in time; we must go forward, and at the rate at which time chooses to travel. We are on a moving platform, the mechanism of which is beyond our control.

There is a difference also in our measures of space and time. Space may be measured in feet, square feet or cubic feet, as the case may be, but time is essentially one-dimensional. Square hours or cubic seconds are meaningless terms. Moreover, no connection has ever been recognized between space and time measures. How many feet make one hour? A meaningless question, you say, yet something that sounds very much like it has (since Minkowski) received the serious attention of many otherwise reputable scientific men. And now comes Einstein, rudely disturbing these old-established concepts and asking us to recast our ideas of space and time in a way that seems to us fantastic and bizarre.

What has Einstein done to these fundamental concepts?

He has introduced a correlation or connecting link between what have always

[1] Publication approved by the director of the Bureau of Standards of the U. S. Department of Commerce.

been supposed to be separate and distinct ideas. In the first place, he asserts that as we move about, the geometrical properties of space, as evidenced by figures drawn in it, will alter by an amount depending on the speed of the observer's motion, thus (through the concept of velocity) linking space with time. He also asserts in the second place that the flow of time, always regarded as invariable, will likewise alter with the motion of the observer, again linking time with space.

For example, suppose that we, with our instruments for measuring space and time, are located on a platform which we believe to be stationary. We can not be altogether certain of this, for there is no other visible object in the universe save another similar platform carrying an observer likewise equipped; but when we observe relative motion between our platform and the other it pleases our intuition to suppose our platform at rest and to ascribe all the motion to the other.

Einstein asserts that if this relative velocity were great enough we might notice some strange happenings on the other platform. True, a rather high velocity would be necessary, something comparable with the speed of light, say 100,000 miles a second; and it is tacitly assumed that we would be able to get a glimpse of the moving system as it flashed by. Granting this, what would we see?

Einstein asserts that if there were a circle painted on the moving platform it would appear to us as an ellipse with its short diameter in the direction of its motion. The amount of this shortening would depend upon the speed with which the system is moving, being quite imperceptible at ordinary speeds. In the limit, as the speed approached that of light, the circle would flatten completely into a straight line—its diameter perpendicular to the direction of motion.

Of this shortening, says Einstein, the moving observer will be unconscious, for not only is the circle flattened in the direction of motion, but the platform itself and all it carries (including the observer) share in this shortening. Even the observer's measuring rod is not exempt. Laid along that diameter of the circle which is perpendicular to the line of motion it would indicate, say, ten centimeters; placed along the shortened diameter, the rod, being itself now shortened in the same ratio, would apparently indicate the same length as before, and the moving observer would have no suspicion of what we might be seeing. In fact, he might with equal right suppose himself stationary and lay all the motion to the account of our platform. And if we had a circle painted on our floor it would appear flattened to him, though not to us.

Again, the clock on the other observer's platform would exhibit to us, though not to him, an equally eccentric behavior. Suppose that other platform stopped opposite us long enough for a comparison of clocks, and then, backing off to get a start, flashed by us at a high speed. As it passed we would see that the other clock was apparently slow as compared with ours, but of this the moving observer would be unconscious.

But could he not observe our clock?

Certainly, just as easily as we could see his.

And would he not see that our clock was now faster than his? "No," says Einstein. "On the contrary, he would take it to be slower."

Here is a paradox indeed! *A*'s clock appears slow to *B* while at the same time *B*'s clock appears slow to *A*! Which is right?

To this question Einstein answers indifferently:

"Either. It all depends on the point of view."

In asserting that the rate of a moving clock is altered by its motion Einstein has not in mind anything so materialistic as the motion interfering with the proper functioning of the pendulum or balance wheel. It is something deeper and more abstruse than that. He means that the flow of time itself is changed by the motion of the system, and that the clock is but fulfilling its natural function in keeping pace with the altered rate of time.

A rather imperfect illustration may help at this point. If I were traveling by train from the Atlantic to the Pacific Coast it would be necessary for me to set my watch back an hour occasionally. A less practical but mathematically more elegant plan would be to alter the rate of my watch before starting so that it would indicate the correct local time during the whole journey. Of course, on a slow train less alteration would be required. The point is this: that a timepiece keeping local time on the train will of necessity run at a rate depending on the speed of the train.

Einstein applies a somewhat similar concept to all moving systems, and asserts that the local time on such systems runs the more slowly the more rapidly the system moves.

It is no wonder that assertions so revolutionary should encounter general incredulity. Skepticism is nature's armor against foolishness. But there are two reactions possible to assertions such as these. One may say: "The man is crazy" or one may ask: "What is the evidence?"

The latter, of course, is the correct scientific attitude. To such a question Einstein might answer laconically: "Desperate diseases require desperate remedies."

"But," we reply, "we are not conscious of any disease so desperate as to require such drastic treatment."

"If you are not," says Einstein, "you should be. Does your memory run back thirty years? Or have you not read, at least, of the serious contradiction in which theoretical physics found itself involved at the opening of the present century?"

Einstein's reference is to the difficulty which arose as a consequence of the negative results of the famous Michelson-Morley experiment and other experiments of a similar nature. The situation that then arose is perhaps best explained by an analogy.

If we were in a boat, stationary in still water, with trains of water-waves passing us, it would be possible to determine the speed of the waves by timing their passage over, say, the length of the boat. If the boat were then set in motion in the same direction in which the waves were traveling, the apparent speed of the waves with respect to the boat would be decreased, reaching zero when the boat attained the speed of the waves; and if the boat were set in motion in the opposite direction the apparent speed of the waves would be increased.

If the boat were moving with uniform speed in a circular path, the apparent speed of the waves would fluctuate periodically, and from the magnitude of this fluctuation it would be possible to determine the speed of the boat.

Now the earth is moving around the sun in a nearly circular orbit with a speed of about eighteen miles per second, and at all points in this orbit light waves from the stars are constantly streaming by. The analogy of the boat and the water-waves suggested to several physicists, toward the close of the nineteenth century, the possibility of verifying the earth's motion by experiments on the speed of light.

True, the speed of the earth in its orbit is only one ten-thousandth of the speed of light, but methods were available of more than sufficient precision to pick up an effect of this order of magnitude. It was, therefore, with the greatest surprise, not to say consternation,

that the results of all such experiments were found to be negative; that analogy, for some unexplained reason, appeared to have broken down somewhere between mechanics and optics; that while the speed of water-waves varied as it should with the speed of the observer, the velocity of light seemed completely unaffected by such motion.

Nor could any fault be found with method or technique. At least three independent lines of experiment, two optical and one electrical, led to the same negative conclusion.

This breakdown of analogy between mechanics and optics introduced a sharp line of division into physical science. Now since the days of Newton the general trend of scientific thought has been in the direction of removing or effacing such sharp lines indicating differences in kind and replacing them by differences in degree. In other words, scientific thought is monistic, seeking one ultimate explanation for all phenomena.

Kepler, by his study of the planets, had discovered the three well-known laws which their motion obeys. To him these laws were purely empirical, separate and distinct results of observation. It remained for Newton to show that these three laws were mathematical consequences of a single broader law—that of gravitation. In this, Newton was a monistic philosopher.

The whole of the scientific development of the nineteenth century was monistic. Faraday and Oersted showed that electricity and magnetism were closely allied. Joule, Mayer and others pointed out the equivalence of heat and work. Maxwell correlated light with electricity and magnetism. By the close of the century physical phenomena of all kinds were regarded as forming one vast, interrelated web, governed by some broad and far-reaching law as yet unknown, but whose discovery was confidently expected, perhaps in the near future. Gravitation alone obstinately resisted all attempts to coordinate it with other phenomena.

The consequent reintroduction of a sharp line between mechanics and optics was therefore most disturbing. It was to remove this difficulty that Einstein found it necessary to alter our fundamental ideas regarding space and time. It is obvious that a varying velocity can be made to appear constant if our space and time units vary also in a proper manner, but in introducing such changes we must be careful not to cover up the changes in velocity readily observable in water-waves or sound waves.

The determination of such changes in length and time units is a purely mathematical problem. The solution found by Einstein is what is known as the Lorentz transformation, so named because it was first found (in a simpler form) by Lorentz. Einstein arrived at a more general formula and, in addition, was not aware of Lorentz's work at the time of writing his own paper.

The evidence submitted so far for Einstein's theory is purely retrospective; the theory explains known facts and removes difficulties. But it must be remembered that this is just what the theory was built to do. It is a different matter when we apply it to facts unknown at the time the theory was constructed, and the supreme test is the ability of a theory to predict such new phenomena.

This crucial test has been successfully met by the theory of relativity. In 1916 Einstein broadened his theory to include gravitation, which since the days of Newton had successfully resisted all attempts to bring it into line with other phenomena. From this extended theory Einstein predicted two previously unsuspected phenomena, a bending of light rays passing close by the sun and a shift of the Fraunhofer lines in the solar spectrum. Both these predictions have

now been experimentally verified. This aspect of the subject has been elsewhere discussed by the present writer.[2]

Mathematically, Einstein's solution of our theoretical difficulties is perfect. Even the paradox of the two clocks, each appearing slower than the other, becomes a logical consequence of the Lorentz transformation. Einstein's explanation is sufficient, and up to the present time no one has been able to show that it is not necessary.

Einstein himself is under no delusion on this point. He is reported to have said: "No amount of experimentation can ever prove me right; a single experiment may at any time prove me wrong."

Early in the present year Einstein again broadened his theory to include the phenomena of electricity and magnetism. This does not mean that he has given an electromagnetic explanation of gravitation; many attempts of this kind have been made, and all have failed in the same respect—to recognize that there is no screen for gravitation. What Einstein has done is something deeper and broader than that. He has succeeded in finding a formula which may assume two special forms according as a constant which it contains is or is not zero. In the latter case the formula gives us Maxwell's equations for an electromagnetic field; in the former, Einstein's equations for a gravitative field.

But in spite of the formal success of Einstein's attempt to bring order into theoretical physics, his theory lacks the cordial support of many persons, including a certain number of conscientious scientific men. To conservative minds his theory has no natural attractiveness. By some such it is accepted on a purely tentative basis, for lack of a better explanation, while others refuse to accept it at all, as fantastic, bizarre and opposed to common sense.

But the history of science teaches us the danger of relying too much on common sense. When Mayer, in the nineteenth century, came to the conclusion that work could be converted into heat, his doctrine seemed as fantastic to the Victorian physicists as Einstein's theory appears to any one to-day. The *Annalen der Physik* refused to publish Mayer's paper. One of his critics said to him: "Why, man, this is against common sense! If what you say were true, water could be warmed by merely shaking it!"

Mayer felt the force of this argument, and for some time could find no reply. Finally, weeks later, it is said, he walked into his friend's presence and without preface announced: "It is!"

Common sense is a great turncoat. To-day, if any one were to assert that water could be shaken without being warmed, he would have the common-sense argument used against him. "Common sense" is too often a synonym for inherited and traditional modes of thought. As Eddington says, the cosmos is undoubtedly regulated by sense, but not always by common sense.

With the honest doubter of relativity the writer has unlimited sympathy, for he himself was for some years of that company. Such a one is in no comfortable frame of mind. He knows that scientific questions are not decided by majorities; he remembers the long reign of the phlogiston theory and the later N-ray delusion, but he can not witness without misgivings the steady movement of his respected fellow scientists to enlist under the Einstein banner.

There is a disease to whose insidious attack every one of us is liable. Let us call it psychosclerosis. When one has thought in a certain way for a long time it is often difficult to see the force of the evidence for anything revolutionary.

[2] "The Common Sense of the Theory of Relativity," SCIENTIFIC MONTHLY, December, 1923; "The Present Status of the Theory of Relativity," SCIENTIFIC MONTHLY, July, 1926.

The great Agassiz never accepted the doctrine of evolution, though every one of his students did. Kelvin to the end of his days found it difficult to believe that the energy emitted by radioactive bodies came from within the atom. He clutched at straws, searching for some unsuspected type of radiation in space, absorbable only by those bodies which we call radioactive.

Psychosclerosis, it seems, may develop at any age. Some exhibit it before reaching years of discretion; others, a few fortunate ones like Lorentz, may remain plastic to the end of the chapter. It will be well worth while for any honest doubter of Einstein to give this point serious consideration. The writer himself was for some years unable to see the force of the evidence, but largely in consequence of the failure of an experimental venture of his own which was designed to prove Einstein wrong, he (like his namesake nineteen centuries ago) saw a great light, and has since been a supporter of the doctrine of relativity.

Einstein's aim from the first has been to bring order, not confusion; to exhibit all the laws of nature as special cases of one all-embracing law. In his monism he is unimpeachably orthodox.

But there are other monistic philosophers besides scientific men. You will recall Tennyson's vision of

> One law, one element,
> And one far-off, divine event
> To which the whole creation moves.

SCIENCE AS A SOURCE OF IDEAS

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A DISCUSSION of this subject necessarily must be founded upon an understanding of two terms—science and idea. An idea may be defined as a definite mental conception believed to be true or possible, and I shall accept that definition provided *belief* is based upon systematized foundational knowledge. Unsupported belief is nothing more than a guess. Guessing has no limitations and it can be applied by any one to everything.

Aristotle believed that if two balls, equal in size but differing in mass or weight, were dropped from the same height at the same time, the heavier would fall more rapidly than the lighter one. This conception was not founded upon knowledge. It was not a sound idea; it could never be a valuable idea; it was not a good idea, and doubtless it was not a new idea. It was a guess, nothing more, even though it appeared reasonable. Many persons unacquainted with science and uninhabited with the modern spirit of experimentation would even now make the same guess. Aristotle had an idea wholly devoid of knowledge. Our definition of an idea is not broad enough to include such an idea as Aristotle's, for I shall consider *valuable* ideas as the only kind having their source in science. Scientists, temporarily out of their rôle or off their scientific base, can have poor ideas, too, but science should not be blamed for scientists. However, scientists associated with organized knowledge and basing their reductions upon established facts have to listen to more poor ideas without the foundation of knowledge than they can possibly create in all their off moments.

If Jules Verne in one of his fascinating tales had included a telescope by means of which one of his supermen could see the past history of the earth, in my opinion this would not have been an idea. I would not credit him with even a part of a valuable idea because many could and perhaps have made the same guess or have indulged in this same fancy without any consideration or knowledge of how the telescope could be made to yield the results. But if I should devise a super-telescope in my mind, in which optical magnification was pressed to its practical limit, then light was converted into electricity, then the electricity was enormously amplified, then electricity was converted into light, this would be a reasonably sound idea, because in the main it is theoretically possible. Then if, in my mind's eye, this super-telescope were directed upon the minutest mirrors—facets of crystals—on far-off celestial bodies, owing to the finiteness of the velocity of light I could see the past events upon the earth. By choosing mirrors at various distances, measured in light-years, I could see any past event which the weather conditions then and now permitted. The whole is an idea constituting a device and its applications. If this apparently theoretically possible idea could be realized in a practical device it would be valuable.

If it should have occurred to me when I was a boy that it would be desirably convenient to charge a storage battery by heating it in the kitchen stove, this would not be a sound idea as far as I was concerned. In fact, at best it would be a wild guess because at that time I knew nothing of the laws of thermody-

namics. However, if I had had sense enough to take this thought to a scientist and he found that it did not transgress thermodynamical laws I would have been entitled to some measure of credit. However, it was not the original thought, but the action, which entitled me to share in the eventually soundly constructed idea.

About three hundred years ago the greatest idea of all the ages took definite form. It was the idea of science—knowledge produced by experimentation. It was the result of an awakening to a new conception of nature—that nature was ruled by law rather than by a capricious or whimsical god and, therefore, that nature could be understood and was worth understanding.

Galileo was one of the first standard-bearers of the new idea. He tested a long-standing belief by dropping two balls, of the same size but of unequal weight, from the same height, and found that Aristotle and all who believed with him for two thousand years were wrong.

The great idea which took definite form at that time was born in a belief-ridden civilization. A new group—scientists—was born into that world. Then began a great struggle which is still going on—between beliefs and knowledge. I do not refer to the so-called spiritual world, but to the material one. A scientist in his proper rôle can have a two-compartment mind. In one he is entitled to beliefs pertaining to the spiritual world, if they brighten his outlook upon life, even though they are not supported by a shred of knowledge. In the other compartment there is no need for beliefs. It contains facts—tested and testable ones—coordinated into laws—systematized. There is no doorway between these two compartments and, therefore, there can be no actual intermingling. Furthermore, there can be no true conflict between the two because they have nothing in common.

Of course, in the present discussion we are interested only in the material world of obtainable scientific knowledge. Science has no need for the word *belief* and the scientist either knows or he does not. Belief ranges from the slightest suspicion to complete assurance. Knowledge either is or it isn't. Of course, there are many gaps in knowledge and the scientist often must make his best guess in spanning them. Perhaps he may be said to believe this or that. But after all it is not belief; it is merely his best guess.

Knowledge alone is not science. It is a mass or mess of facts. The knowledge which comes by individual experience is so often faulty and fragmentary that only the knowledge tested by the experience of many, and then only by methods which minimize the effects of emotions and prejudices, is dependable. Science is the organization of these tested facts into relationships—into law and order. When the facts are insufficient, some guessing must be done as to the final relationships. Hypotheses are created. As the gaps decrease by the addition of new knowledge, theories evolve. Finally, when no gaps remain, the relationship is a law. Laws are then grouped into generalizations. What seemed to be a complex disorder has evolved into simplicity, revealing much of the workings of nature. Since the man of science is saturated with tested facts and with laws and principles, the probability of his guess being correct is greater than that of the guesses of others.

Individual facts can be put together into various patterns. These more or less complete patterns are ideas. It is in this way that the scientist or others may create valuable ideas. Inasmuch as it is inconceivable that any new idea can be so simple as to arise from a single fact, it may be concluded that all eventually valuable ideas are constructed from systematized knowledge. Therefore, science is the source of the material of all valu-

able new ideas. Sometimes the scientist creates the idea but often he does not, and he has several good alibis when he does not originate the idea. Even with the necessary facts before him often he fails to see the combination which leads to a new application of knowledge. He has no alibi for this excepting that he is merely human.

If we take all historical time beginning seven thousand years ago as being equal to the lifetime of a human being, the three hundred years since Galileo correspond to a three-year-old child. On this scale organized scientific research is an infant only three months old. The birth of the three-year-old changed the entire philosophical outlook of free-thinking men. It began an intellectual revolution and it established the necessary foundation for the material revolution which was to come later. More than two centuries elapsed before this pure-science outlook gave birth to organized research with an applied-science view-point. For the first time in all history lines of communication began to be partially established between industry and systematized fundamental knowledge. Even with these few and uncertain connections this three-months'-old infant has already revolutionized industry and man's manner of living. And this, notwithstanding a general lack of recognition or understanding of the functions of science and of scientists on the part of the commercial, industrial and engineering elements which necessarily are links in the lines of communication between science and public needs and demands.

Industry is as old as civilization. It is of the belief-ridden age and it has inherited much which still blinds it to the fundamentality and certainty of science. It evolved from a realm of uncertainty —of opinions, beliefs and partial truths —and it still uses these in creating, examining and in weighing ideas. It still does not completely comprehend that a foundation of tested systematized knowledge is available. When such knowledge is not incomplete or wholly unavailable, at least there is available in the scientist a more or less perfected art of research attack. Commercial and technical men, having grown out of the age in which the cart was before the horse, naturally tread blandly and blindly into the scientists' field instead of recognizing that they are only links between science and the public. Scientists, having sprung up recently, with no traditions and with no preordained place in business and industry, naturally tread uncertainly and often unwelcomed where others have long been established. As a consequence, the lines of communication necessary for the creation of valuable ideas are not as good as they should be.

When organized scientific research with an applied-science view-point got well under way, much was heard of pure science and applied science. For two hundred years following Galileo, scientific studies were pursued predominantly for the joy of discovery or, in that age of aristocracy, for the intellectual superiority which was the badge of such work. There developed an aristocracy of knowledge. Some scientific men even expressed the hope that their works would never be degraded by being useful. Twenty years ago there were still many of these aristocrats of knowledge accepting a living from a civilization which they, secretly at least, disdained to aid. Science and scientists have paid dearly for this attitude. But research from an applied view-point, vibrant with purpose and energetically alert, has made a name for itself, brought prosperity to those who paid the bill and much comfort and happiness to mankind. Applied or industrial scientists also made many fundamental discoveries and other additions to funda-

mental knowledge. To-day the pure scientist is rare who looks down upon the applied scientist. The aristocrats of knowledge are threadbare and antiquated. Applied research has become intellectually the peer of pure research. It is also much more difficult because it must surmount the obstacles in the path toward the objective. And the most serious obstacles are often the prejudices and other weaknesses of human beings in the path. Pure research is not as purposeful nor as definitely committed to an objective. It is more likely to detour or digress when the going becomes too difficult or seemingly impossible. As a consequence the relatively greater hardships have made industrial scientists as a rule more virile than the pure scientists. They are also more alert to the opportunities of science because at least they are on the edge of the maelstrom of the world's affairs, whereas pure scientists are relatively isolated.

Science necessarily supplies the material of which all valuable ideas are constructed. However, to pursue this subject further we must dissect an idea until we find what we may call the germ. One may dream or even investigate without purpose. These germs float in and out of the mind. If purposeful thinking takes hold of such a germ and the mind is stocked with systematized tested knowledge, a valuable idea may result and a poor idea will be recognized. For one mind to catch the germ and build it into a valuable idea has become increasingly difficult. In the early years of applied science there was great opportunity for the individualist. That was the heyday of the Edisons. Only as a new branch of science is opened are such opportunities available. They will come from time to time, but with less and less opportunity for the individualist. This century has witnessed the evolution from simplicity to complexity in all phases of science and industry.

Likewise civilization has grown complex. There was a time when every individual was relatively independent. He supplied all his needs. But times have changed. In addition to obtaining, possessing and using systematized tested knowledge, the scientist can not be expected to be the major creator of valuable ideas, the inventor, the manufacturer and the seller of the article any more than any individual can be expected to supply all his own needs in the present age. Still, under certain conditions of organization and human obstacles he must do all this. The industrial scientist at times should play all these parts or parts of each, but it is becoming increasingly difficult.

Science has grown very complex and extensive in its three hundred years of life, largely because of the universal availability of knowledge through printing and other kinds of communication. The scientist must keep his mind's eye upon this kaleidoscope of scientific works and publications. Besides his own studies he must file away for present and future use as much of this knowledge as possible. While doing this the world moves onward, public needs alter and the applications of products ramify. To obtain the greatest number of valuable ideas for his company he should have at least four lives to live in parallel. One would be spent out in the public's world learning what the public thinks, needs, desires and is getting from other sources. One life would be spent among the salesmen and engineers. One life would be lived inside the industry. One life would be given to his own studies. The germs of valuable ideas are to be found in all these places. He can do his best to spend some of his time in all these rôles and should create as many ideas as others equally concentrated upon their respective fields. But the most productive organization would be the connecting of these individuals or branches in such a manner that com-

bined they form a complete line of communication. But until the other links obtain a full conception of what science is and where it is to be found, germs of ideas which they catch may die before they can be built up with systematized knowledge.

Even in a progressive industrial organization it is not difficult, for one possessing the scientific view-point, to see the opportunities of science being wasted daily. Either the germ of an idea is not brought to science or science is not where the germ is. Of course, science is constantly producing, but I am trying to show how it could do more. For years I have seen technical researches and other activities being pursued by men who did not have a grasp of the fundamental laws and data underlying the work. Furthermore, there is an art of research which is best developed in those who have a clear conception of science and are guided by its spirit. Possibly science could be made to yield more valuable ideas if these technical men would develop the library habit. To one in the scientific field in which the reading or skimming of scientific journals has necessarily become a habit, the prevalent lack of acquaintance with the scientific work of the world on the part of most technical men engaged in researches and allied activities is shocking.

However, for an industry to get the most out of science, scientists should be intimately associated with technical departments and activities. Consolidation of these various view-points and talents establishes the best lines of communication and provides the greatest exposure to germs. Then, regardless of who catches the germ, it may be built into a valuable idea by the combined knowledge of the various individuals, and the waste due to poor ideas should be decreased. It is difficult to conceive of consolidation going so far as to include science with commercial activities, but the scientist, if he had the daily experiences of the commercial men, would catch many germs and some of them would become valuable ideas.

One of the difficulties is the temporal displacement of view-points. Primarily the salesman is interested in to-day; the commercial engineer in next month; the technical investigator in next year, and the industrial scientist in the more distant future. But they have in common the success of the business. To insure continued success, progress in products must be made. Each of the elements can play some part, however small, in catching germs and in passing them back along the line. Perhaps it may seem that I have gone somewhat afield in this discussion. I have purposely covered most of the territory where germs of ideas may be found in order to emphasize the importance of action and to show who can be active in aiding science to aid in industry.

Knowledge is valuable, but action is necessary. In the early years of applied science in industry, scientific knowledge was relatively meager but also most of its simplest applications had not been made. The industrial scientist had not arrived, but technical workers were already at work. By action they made up for the scarcity of scientific knowledge, in some degree at least. In that simpler period of simpler ideas and developments, action was generally more fruitful than thought. It was fruitless to think without scientific data, for this is the thought-stuff. That was the period of learning how; the era of knowing why was yet to come. Those were the years when, as Edison said, one was wise to try a fool experiment.

Since that time scientific knowledge has increased enormously in quantity and in complexity. In the development of ideas, thought has relatively increased in importance. Its fruitfulness increases

correspondingly with scientific knowledge which provides the stuff for thinking. Action, including keen observation with an alert mind, will always be necessary, and all the individuals in the line of communication between science and its applications must supply a part of the action if the utmost is to be obtained from science.

It is unnecessary to review the services which science has already rendered to modern industry. It has played an important part in the development of valuable ideas—sometimes including the germ stage, ofttimes afterward. With organizations designed to expose science to germs and germs to science, it should do increasingly more. It has many advantages. It is able to separate the ideas which are mere guesses from those which are sound. It always produces the valuable species of ideas. Some may not be economically valuable to a company but it is not necessarily the function of science to determine or to predict this. Any sound idea, however valueless from an economic view-point at the present time, will be valuable sometime, for it is inconceivable that in this complex world, which is growing more complex, any group of facts arranged into a sound idea could not be useful sometime somehow. Science eliminates haphazardness not only in the choice but also in the development of an idea. Science works directly with open eyes. A great amount of industrial research and development work is being prosecuted more or less blindly at the present time. The worker is blind in proportion to his lack of fundamental knowledge underlying his work and between him and his objective. The scientist is a sharpshooter with a modern rifle. The worker without scientific knowledge is using an antiquated blunderbus.

To accomplish the task which I have assumed, I shall utilize a recent idea created by Einstein. He found a way of confining a boundless universe in a limited space. He did this by inventing curved space, which gave a curvature to the universe. If an earth-being got astride a ray of light emitted and traveled in a straight line, as light is supposed to travel, eventually he would find himself at the place from which he began his journey. Any discussion involving science is boundless because science is. Still it must be limited. In order to be certain to confine a boundless subject in a limited space, I decided in the beginning to stop where I began. Before Einstein's invention, this could have been accomplished only by arguing in a circle, but I have Einstein to prove that I can do this by traveling in a straight line.

As I return toward the starting-point I find knowledge and science incompletely defined. I shall now complete the definition and correspondingly develop the picture of science. Since scientists came upon the stage of civilization, a new kind of knowledge has appeared. Before their time fundamental knowledge, at best, was qualitative. Little is really known concerning anything until it is measured quantitatively. We see a moving object. That alone is the type of knowledge of the prescience era. Measurements of direction, speed, size, shape, mass and constitution are the foundation and the framework of scientific knowledge. This kind of accurate detailed knowledge leads to a larger sphere of understanding by answering such questions as, When and why did the body start? What keeps it moving? Where is its destination? From these answers arise other questions and the sphere of relationships grows and grows.

The scientist develops measuring instruments more and more sensitive, and mathematics more and more adequate. These are the tools which have given us detailed knowledge. Without highly

accurate measuring methods Einstein would never have known the errors of Newtonianism. Without the most recent developments in mathematics he would not have been able to express himself. Without these we would still be in the pre-Einstein era of knowledge.

And so it goes on and on—the scientist is continually sharpening his tools, inventing new ones and extending their use. His production is detailed intimate expressive knowledge, and we profit greatly by some peculiarities of this product. Knowledge is invaluable; still, it can be given away without parting with it. Perhaps this is the major reason for its wide distribution. Knowledge is useless until it is used and it still exists after it is used. Certainly this is a good reason for using it. With these characteristics and the inestimable results of scientific knowledge in a relatively few years, should we wonder that civilization which got along without it for many centuries has adopted it for its foundation and is growing more and more dependent upon it?

In the earlier years of Edison, scientific knowledge was so meager that many simple ideas and developments awaited the technical worker. Edison himself discovered the phenomenon of electronic discharge between the terminals of a filament lamp. But he only learned that an electric current passed through the space between. The electron had not been discovered because measuring methods had not been developed to detect it. The entire radio art has been constructed since 1910 upon the accurate quantitative measurements of the preceding twenty years. Qualitative knowledge is only a step nearer certainty than opinions and beliefs. Accurate quantitative data are the essence of truth and certainty.

This is the kind of knowledge we can depend upon, and prejudices, emotions, opinions should not be permitted to hamper it. This is the kind of knowledge which is teaching us that more than man can imagine nature can achieve. This is the kind of knowledge that men, mere motes on an almost infinitesimal earth, are obtaining from atoms inconceivably small and from stellar laboratories inconceivably distant. Measuring instruments are limited, but the human mind is boundless, just as the universe is limited although it is boundless. Man's equipment is well adapted to explore all nature and to learn its secrets.

And the benefit of scientific knowledge should not and will not end with its utilization in material things. Only genius can extend the borders of scientific knowledge, but the humblest man can be taught its spirit. He can learn to distinguish between opinion and knowledge. He can learn to desire, to know and to face truth. Doubtless, human beings will always have their frailties, but as the scientific spirit infiltrates more and more throughout business and industry, and thence throughout civilization, it should develop honesty and tolerance and make better human beings. What can compete with the shrine of truth?

THE FOSTER CHILD

By PAUL POPENOE
PASADENA, CALIFORNIA

MOST of the children available for adoption fall into three groups: (1) illegitimate children; (2) those abandoned by their parents; and (3) those who have been taken away from their parents because the latter were found unfit by the courts to retain the custody of their own offspring.

It is scarcely necessary to point out that in none of these cases is the ancestry likely to be up to par. The best are sorted out early by the child-placing agencies, in response to the demand for children to adopt, which everywhere in the United States exceeds the supply, girls being most desired. The remainder, collected in orphanages, represent predominantly the inferior levels and usually show up badly in tests. Congenital syphilis is abundant; superior intellect rare. Numerous examinations of the populations of such asylums have revealed that from one eighth to one half of the inmates may be classed as "normal." Most of the rest are either mentally deficient or at least backward; there are usually a few above the average, the proportion of these running in some instances as high as one eighth.

A group of 513 dependent children in Delaware, studied by the Children's Bureau, probably represents conditions in many other states. More than three fourths of these came from families in which there were unfavorable conditions, alcoholism and "immorality" being the commonest findings. Only 3 per cent. of the children were full orphans; most of them had both parents living but "no account." Three fourths of the children over seven had themselves records of delinquency.

Special studies made upon illegitimate children harmonize with these findings. An investigation in Boston showed that "at least 19 per cent. had a heritage in which there was known or probable insanity, feeblemindedness, or other subnormal or abnormal mental condition," while mental examinations of a series of unselected unmarried mothers from the obstetrical service of the Cincinnati General Hospital disclosed that "not more than 20 per cent. can safely be pronounced normal. From 40 per cent. to 50 per cent. of the unmarried mothers are almost without question of so low grade mentally as to make life under institutional care the only happy one for themselves, and the most economical and only safe arrangement for society."

Yet in another investigation the illegitimate children were found to be brighter and of better parentage than the legitimate children that were placed out. Among the latter, 89 per cent. of the fathers and 83 per cent. of the mothers were described as "either mentally or morally defective," as against 31 per cent. and 53 per cent. for illegitimates. Of course such figures are not exact, but they confirm the everyday knowledge that children from good homes are not customarily out looking for foster parents.

Reputable child-placing agencies, however, make every endeavor to place children under conditions that will be favorable. So far as possible, those with congenital syphilis are not sent out, unless to some one who understands the situation fully. If the child is old enough to be tested, its mentality is determined and the prospective foster parent advised. Ancestry, tradition, religion are taken into account. Among younger children the agency has little

chance to predict intelligence, and its clients seem to attach little weight to this. Most people stipulate that the child they are to take shall be healthy; apart from this they are more concerned about inconsequential and sentimental items than about the fundamentals, their attitude in this respect recalling that of many younger persons in selecting a husband or wife. Often a demand is made for a child on the spur of the moment. There is an authentic story of a woman who suddenly decided to adopt a baby shown her, because she thought it "would look so sweet" in a coat she could make from some pieces of left-over white fur. The sweet little thing thus adopted now has an IQ of 72.

A distinguished physician who is one of the most active men in the United States in promoting adoptions describes the situation gleefully. "People come up looking for girls," he says. "Of course they must all be golden-haired, blue-eyed, with dimples, impeccable ancestry and sweet dispositions. But all we do is to take the prospective parents up to the nursery, and some child holds out its arms to them, and it may be a black-haired boy picked up in an open lot somewhere, but they say, 'That's the baby I want.' "

A child who is placed in a foster home after the age of four or five knows, of course, that it is not his real home. Those placed earlier may not know unless told. In a New York investigation, half of the children placed under five were kept in ignorance of the foster relationship, while in a California investigation which dealt only with those adopted as infants, two thirds were ignorant. In this case, it was found that the most intelligent parents were the ones most likely to tell the child the truth.

Although hundreds of children are being placed out each year by scores of agencies, some of these show little concern over the future of their charges. They prefer to content themselves with pious hopes and fervent affirmations, and cite a few striking instances to justify the claim which most of them make, explicitly or implicitly, that any child will turn out well if given a proper home.

Such an exceptional child was probably the offspring of the black sheep of some able family. While his own parents may have been of little value, or even a detriment, to the community, they were yet able to transmit to their offspring good qualities which did not appear in their own lives. Thus one would expect, in a large group of dependent or illegitimate children, to find a few who carried some really good traits. There are a few other cases where a child of superior parents is set adrift for some unusual reason. Moses is the classical example, but Sargon I, king of Babylonia (2637–2582 B. C.), has almost identical childhood history and is an equally striking case in point.[1]

These isolated cases are easily matched by equally isolated and striking cases to the opposite effect, such as two boys (reported by L. M. Terman) adopted at the ages of five and seven from a very poor home. Their IQ's were 72 and 73. Four years later, after exceptional advantages, their IQ's were 70 and 77.

So far as I am aware, only one agency which places children has made any determined effort to find out how its children turn out. This is the State Charities Aid Association of New York,

[1] The number of legendary worthies whose supposed parents were not their real parents has aroused the ready suspicion of the psychoanalysts, and they have described "The Birth of the Hero" as one of the universal myths, based on an equally universal tendency of children to fancy, in their day-dreams, that they are not the offspring of their putative parents, but are really of nobler lineage. Questionnaires reveal that a large proportion of the population does, in fact, recall having such childhood fantasies. The number of histories comparable to those of Sargon and Moses can be multiplied readily by any one with a knowledge of ancient literature.

which published in 1924 a report on the history of 910 of its children. Briefly, it found that six out of every eight have "made good" in the sense that they have at least been able to manage their own affairs with ordinary prudence and live in accordance with the standards of their own communities. The seventh has turned out to be incapable but "harmless"; the eighth, definitely bad.

Although three fourths of the children are thus alleged to have become reasonably good citizens, this fact is not quite so encouraging as it appears at first sight to the family which contemplates taking in or adopting a child (only 269 of the children in this group were legally adopted), for the fact is that some of them had to go through two, three or more homes before they found one in which they could live satisfactorily. There were 1,621 homes used for the 910 children. In only 60 per cent. of the homes did the child turn out satisfactorily. It thus appears that the family contemplating taking in a foundling has a little better than an even chance not to regret the act.

Moreover, it must be remembered that this particular agency, which is one of the largest in operation, probably sifts its children with unusual care, to eliminate defectives. A smaller agency run with less efficiency and more sentimentality would be likely to place many children who were even less favorably endowed.

Furthermore, the children included in this study were in some cases still young—nearly half were minors. It is obvious that their "success" at the age of eighteen is not final, since they are mostly still under the control of their elders. The child who appears at eighteen or twenty to be behaving well may at twenty-eight or thirty tell a different story. At the lower age he is either still dependent or is just releasing himself from his dependent status. What will happen ten or twenty years later, when he is married, has more children than he can support, loses his youthful ideals, ambition and self-confidence, and begins to think that "the world has it in for him" and that it is no use to try to be a good citizen, since the ones who get ahead in life are merely the crooks who are clever enough to avoid detection?

It appears, then, that this study can not be taken at its face value; that the facts are probably not so favorable as appear from it.

Looking at the details more closely, one learns that the child placed in a bad foster home is just about as likely to turn out well as is the one placed in a good foster home. Even the worst parental home, it seems, is better than the best orphan asylum, if the child's future success in the world is the standard of measurement. These are striking and almost unprecedented findings, which need a good deal of substantiation before they will be accepted without question. The studies quoted later in this paper show that foster children put in good homes frequently made definite, sometimes relatively large, gains in IQ. The home brought out the best that they had in them. On the other hand, two groups of girls taken from bad surroundings and put in unusually good institutions failed to show any such advance. In another case, involving only six girls who were put in a very superior institution on the cottage plan, the average gain was but five points, and one showed a marked loss. Among one hundred children in two German orphanages, there was no relation between the level of intelligence and the length of time that the children had spent in the institution. Brothers and sisters are not made any more alike intellectually by being kept in an orphanage for years.

In all these instances, the institution was doubtless much more impartial, much more efficient, much more hy-

gienic, much more "scientific" than the home. But it failed in comparison with the home because the latter apparently provided something necessary for child development which the former could not furnish. A consideration of this fact is recommended, in passing, to those who think that the old-fashioned family is an obsolete institution, and who look forward to a time when the state will assume the care of all children as soon as they are weaned, thereby setting parents free for "careers."

What, then, in the light of the New York report, makes the difference between the child's success and failure in a foster home? Two factors are named: (1) early placement, and (2) a sympathetic relationship with the foster parents. To some extent (2) is merely a phase of (1). This report, then, puts almost the entire weight of the child's success on being adopted young.

Important as this fact is, few will believe that it is strong enough to support the entire weight of the superstructure. When one looks more carefully at the figures, one finds that of full brothers and sisters, put into equally suitable homes so far as one can judge, 40 per cent. turned out quite differently from each other. Here is the factor of heredity, of which the report had previously lost sight. The parental traits segregate out in the children; some get more than their share of the good ones (and it is scarcely necessary to remark that even the worst family has a few good traits); some get more than their share of the bad.

The conclusions of the study just mentioned are borne out, in part, by two particularly careful studies, one in Illinois (Frank N. Freeman, *et al.*) and the other in California (Barbara S. Burks). These were concerned primarily to find how far the child's general intelligence could be brought up by good surroundings.

The Illinois study is the most nearly comparable with that of the New York agency, for it dealt with children placed out at all ages. The conclusion it reached was that early placement and a good foster home were the most significant features in permitting a child to do his best. Although the background of the children was bad, it was found that in good homes there were few serious cases of misbehavior.

The California study is particularly interesting in dealing only with children placed as babies—all of them under one year of age and most of them at about three months. It therefore had an ideal opportunity to measure the total effect of environment acting after birth. It appears from this study that all of the factors of home environment taken together account for something like 17 per cent. of the differences in intelligence among children. The total contribution of heredity seemed to be about 75 per cent. or 80 per cent. The small remainder must be assigned to the sort of chance and accidental influences that are always present in development.

Of the influence assigned to heredity (75 per cent. to 80 per cent.), a third was allotted to the parents. The rest belongs to the more remote ancestry. Usually, the influence of the parents is thought of, and properly so, as including also that of all their progenitors; but if one is making a separate study of the various influences that account for the differences in IQ among children, it is legitimate to attempt to apportion the responsibility in more detail, as in this instance.

This study also gave an almost unique opportunity to determine how much an IQ could be changed by the greatest possible improvement or impairment of the environment, acting from birth onward. The conclusion was reached that in such extreme conditions, it might be altered as much as twenty points, but

that such extreme conditions would not be reached in more than a home or two in a thousand. Rough as the present methods of measuring mental traits are, then, they do succeed to a useful degree in getting at the real innate intelligence of a child; and 70 per cent. of the average run of school children have an actual IQ within six to nine points of that represented by their innate intelligence—that is, any changes in the ordinary conditions of life would not change the IQ more than six to nine points.

The California study, like others, supports the view that traits of personality and conduct are much more subject to influence from outside than are traits of intellect or physique. They represent social much more than biological aspects of life.

The three studies cited above give, for the first time, a scientific knowledge of some of the results of child adoption. They agree with common sense in showing that a child will do better with every assistance and sympathy than he will do with everything against him; they agree with the conclusion now widely accepted that the conduct of a child is something for which the parents themselves must take the responsibility—they can not blame their great-grandparents for it. But they all have the serious defect that they do not go much beyond the adolescence of the adopted child. What will happen when this child grows up?

Apart from the interests of society, which are a matter of eugenics, there are two interests to consider: that of the foster parents and that of the foster child.

(1) The foster parent desires a child to comfort his declining years; to bring the happiness into his life which only a child can bring. What chance has he to realize this hope by adopting one? As parents go, the chances appear from the New York study to be about even that the child will make him happy, or unhappy. Wise parents will do better than this; but not all parents are wise, especially when parenthood does not come to them until late in life, and then comes only in an artificial way.

The important points seem to be:

(a) To pick out a child with as good ancestry as possible. Bad as the ancestry of illegitimate children is, it has been pointed out above that it is likely to be better than that of legitimate children of the sort that are thrown on the market for adoption. The chief difficulty is that the ancestry is not so easily learned. But the mother is always known, save in the case of foundlings; and while she may conceal the paternity, either because she really does not know, or because she wants to protect the man, his identity can usually be ascertained with a little effort. A knowledge of the ancestry will tell what strong points the child is likely to have which can be developed, what weak points call for continual caution.

(b) The child should be taken young. Here again the illegitimate child has the advantage, for he can usually be gotten much younger than the legitimate child—many maternity hospitals make it a point not even to let the illegitimate mother see her child, if it is to be taken from her and brought up by others. An incidental advantage is that the real parents of an illegitimate child are less likely to make trouble, either for the child itself or for the foster parents, in future years, than are the parents of a legitimate child. One of the chief disadvantages of taking a child very young is that the presence of congenital syphilis is not quite so easily ruled out. Wassermann tests on the baby are not always dependable, nor are those on a pregnant woman, at least as ordinarily made. Here again a knowledge of the ancestry is a safeguard.

(c) The child should be taken only on trial. Many agencies have a fixed period of one year of probation before a child

can be adopted, and in some states a legal adoption may be voided at any time within five years, if desirable. This is a valuable provision for the protection of the child as well as the parents.

(2) The interests of the child are to get the best home possible, and to have the best possible chance in the world. It therefore makes less difference to him if he has to go through four or five homes to find the right one, even though he may have left broken hearts in the others.

On the other hand, it is possible for a child to have too good a home—not merely in the very common sense, in which he has life made too easy for him, as people often make it too easy for their own children; but in the sense that he has a better home than he can live up to. Almost any principal of a private school which receives the children of the leisure class can tell of the differences in ability between the foster children in the school and those "to the manor born." The latter are distinctly beyond the averages of their ages in brightness. The foster child represents a different ancestry; no matter how early he has been adopted and how carefully he has been schooled, he may not be able to make up the difference; he can not compete on even terms with those who started with a better endowment.

The result is that the foster children in such a group, though surrounded by every encouragement to succeed, contrast badly with their associates. They themselves feel this contrast more vividly than any one else, and a common result is the production of an inferiority complex, a feeling of baffled helplessness and resentment, which is likely to lead to a failure of mental adjustment.

Finally, it is not to the interests of the child to make a good marriage and produce defective children. He should at least be warned in this respect, even though the knowledge of the facts of his ancestry may cause pain. It is generally recognized by thoughtful students, I believe, that the child should not be allowed to grow up with the supposition that he is actually the offspring of his foster parents; that the fact of legal adoption, which Henry Maine called "the most violent of fictions," should not be converted into a real lie. The foster child faces in this respect a dilemma, both horns of which are certain to wound deeply. But it can not be escaped.

Any one who thinks eugenically will not want to see the lines of descent falsified by a concealed adoption, and such concealment will probably only store up trouble for the child in years to come.

By a favorable combination of circumstances, some of these children with defective heredity have themselves largely escaped the consequences. They are carrying genes of worse traits than those which are openly expressed in their minds and bodies. These will appear in their own descendants, to the great chagrin of all concerned. These children can not marry wisely in the future without knowing their own ancestry. They can not even avoid the possibility of incestuous matings; and although incest has no biological significance other than that of consanguineous marriage in general, the strong social tabu against it is based on cogent grounds. A young man who fell in love with Ninon de l'Enclos committed suicide when he learned that she was really his grandmother. To give him the benefit of the doubt, however, perhaps he killed himself not from chagrin at making love to an ancestor, but at having such an ancestor. Anyhow, for the child's own benefit as well as that of society, every effort should be made to get at the truth of the heredity, and this should not afterward be concealed or misrepresented.

A HYPOTHESIS OF POPULATION GROWTH

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In size a population varies directly with amelioration of the conditions of existence and inversely with the prevailing level of the standard of living. Here is a hypothesis of population growth expressed in two coordinate clauses. It suggests that a variable, "size of population," is controlled by two other variables, "wealth" and the "standard of living." Our prime variable, size of population, tends to move in the same direction as our second variable, wealth, and in a direction opposite to movements of the third variable, the prevailing standard of living.

The population problem has always been considered the peculiar province of the economist, probably because the lone classic on population was the work of a man who later became a professor of economics.[1] But the two most substantial modern works upon the subject were drawn from the experience of biologists, E. M. East and Raymond Pearl.[2]

The first clause of our hypothesis, "the size of a population varies directly with amelioration of the conditions of existence," has received for nearly a century the close scrutiny of biologists, and it has been generally considered exclusively their property. But the idea was borrowed, in the first place, by Charles Darwin from the work of Thomas Robert Malthus, who was a professor of economics at Haileybury College, England, from 1805 to 1834. "In October, 1838," says Darwin, "that is, fifteen months after I had begun my systematic inquiry, I happened to read for amusement 'Malthus on Population,' and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observations of the habits of animals and plants, it at once struck me that under these circumstances favorable variations would tend to be preserved, and unfavorable ones to be destroyed. The result of this would be the formation of a new species. Here, then, I had at last got a theory by which to work."[3]

Although Darwin called his *magnum opus* the "Origin of Species," the thesis therein contained is not so much a theory of the origin of species as a theory of biologic progress. Modern biologists are not quite sure that the essential differences between a whale and a shark or even between a whale and a sea-lion ever could have been brought about by "variation" and "natural selection." The theory of accidents or sports has been inserted in a supplementary or even supersessive sense. Over-propagation with consequent premature destruction (in the main, selective) is retained, however, as a theory of the progress of individual species and as a theory of the general forward march of life. (The term, "forward march of life," has of course no moral significance; we mean simply adaptation to lodgment which seems to express itself mainly in progressive complexity of structure and concurrent

[1] T. R. Malthus, "An Essay on the Principle of Population," 6th ed. 1826.

[2] E. M. East, "Mankind at the Crossroads." 1923.

Raymond Pearl, "The Biology of Population Growth." 1925.

[3] "Life and Letters of Charles Darwin," edited by his son, Francis Darwin, 1883. Volume I, p. 83. In the opinion of E. M. East, Malthus in turn borrowed his idea from Franklin, who expressed the whole Malthusian principle in "three paragraphs." ("Mankind at the Crossroads," p. 46.)

functional specialization of cells. But a law of diminishing returns seems to come into play here, for mere multiplication of cell varieties on a functional basis can not solve all life problems and *in extremis* must defeat itself—multiple stomachs, and most vestigial forms, bear witness to this fact, although the most complex life form—usually called the highest life form—man, appears to carry off the palm for prevalence and persistence.)

In order to get movement into his hypothesis, Darwin was forced to accept Malthus's central doctrine, over-propagation.[4] Darwin had noted the two prime facts of biologic progress, heredity and variation, and he realized that these two were but the inert groundwork of development; but in over-propagation and consequent pinching out of the least-favored individuals he discovered a motor for his scheme.[5] Darwin's main thesis—that progress and species arise from propagation beyond the means of subsistence—has been importantly reshaped; but the fact of over-propagation, upon which his thesis rests, has stood up under the scrutiny of four generations of biologists. It is to-day one of the central axioms, theories, hypotheses, prejudices—call it what you will—of every biologist: ***All life tends constantly to press upon the conditions of existence.*** Collective life, everywhere and always, tends to exceed the warrant for it. And this is simply a converse statement of the first clause of our hypothesis: "The size of a population varies directly with amelioration of the conditions of existence."

But it is not the growth of population which needs explaining. The universal life-fact of over-propagation, coupled with an enormous and cumulative expansion in human well-being, amply justifies a far greater growth than any population has experienced. "Assuming a doubling in twenty-five-year periods to be well within the historic as well as the physiological limit, the descendants of a single pair living at the time of Christ would to-day be sufficiently numerous so that the entire surface of the earth would furnish standing room for about one eleventh of their number."[6] It is the slowness of population growth and the small size of present-day populations which want explaining. Here then is offered the possibility of an important economy of attention. We may concentrate mainly upon the second clause of our hypothesis: population tends to vary inversely with the prevailing level of the standard of living: our main task is to examine the proposition that the standard of living, in its complete bearing, explains the slowness of population growth.

In brief, the problem of population presents two sharp, clear questions: (1) Why do populations increase? (2) Why do they not increase more rapidly? We find that biologists have answered with unanimity the first question, offering propositions that are supported by a reassuring array of data. But students of population answer the second question with widely divergent opinions. Do the valid portions of all of these opinions find their ultimate explanation in the rising standard of living? Upon this quintessential putting of the question the main weight of our attention must fall.

Let us illustrate the salient features of our hypothesis with an imaginary instance from insect life and a few rough data of population and human well-being. A tiny colony of ants appears in a desk drawer. A few grains of sugar at tea time somehow fell there

[4] Wallace, as well, acknowledges his debt to Malthus; see A. M. Carr-Saunders, "The Population Problem," p. 18.

[5] A fuller statement of the theory of progress appears in a brief essay, "Progress—By Accident or Plan," by the present author, SCIENTIFIC MONTHLY, 20: 159–162.

[6] E. B. Reuter, "Population Problems," pp. 115–16.

and attracted these immigrants. There was food in the region from which they came, but it was not so plentiful as in this new world. Just so has America become peopled with Europeans. An ant, let us say, requires for sustenance one grain of sugar a day. We supply, daily, exactly ten grains; the ant population soon will settle down to exactly ten. If there were originally thirteen ants, three must emigrate or die. There are precisely ten grains of sugar, and that will support ten ants—no more. The rate of propagation is a furious one. That matters not. Ants in other regions get wind of the sugar, and a terrific immigration sets in. Again, no matter. Immigration, emigration, death-rates, birth-rates—all are secondary considerations in the population problem; they are themselves determined mainly by economic circumstances. The controlling fact is the sugar supply, ten grains, that settles it: a population of ten, yesterday, to-day, forever.[7] . . . The population of Nevada per square mile amounts to seven tenths of a person. Nevada's meagerness will support no more. But Massachusetts' humming mill-wheels produce a flow of wealth that supports a population per square mile of four hundred and seventy-nine. More sugar, more ants.

In a burst of open-handedness, we raise the sugar-ration to twenty grains. A few weeks later we take a census—and with what result? To be sure: twenty ants. There was immigration, but no matter; the death-rate slackened; it is quite possible that even the birth-rate may have changed—biologists are not quite clear on that point—but no matter. There is but one point of import: twenty grains of sugar daily instead of ten. Ten grains: ten ants. Twenty grains: twenty ants.

For hundreds of generations, the population of North America (before Columbus) remained nearly stationary at a million and a half:[8] to-day, only four and a half centuries later, it is a hundred times as great. The vast wilderness for thousands of years yielded to bow and arrow sustenance enough for a million and a half of mankind—no more. Then forests were felled, making rich tillage and pasturage. Machinery came, and system, and science, opening richer fields: coal fields, oil fields, iron fields, copper fields, gold fields. A Niagara of wealth poured forth its abundance. Population increased a hundredfold. More grains of sugar: more ants.

Let us see how our little colony is getting on: Twenty grains of sugar, daily, and twenty ants. However absurd, let us say our ants demand a bird-shot each to roll about in play. No; our generosity will not afford so much. But as they insist we compromise on ten shot, and daily, ten grains of sugar. Ten grains of sugar and twenty ants? Yes, ten ants must die. A standard of living that includes both sustenance and play pinches out ten lives. High and unbalanced living-standards are as deadly as natural scarcities.

Cruelly high standards of living check the growth of population as effectively as ever did niggardly nature. In every modern community there are families possessing an automobile, whose children are not properly clothed, or nourished, or doctored. Dressed to look like bankers' sons, young men stand on street corners in winter smoking cigarettes to keep warm, because they have no money for woolen underwear and top coats.[9] Handsome coupés which flash through fashionable boulevards on pleas-

[7] This ant instance—and the material which follows—is not introduced of course to substantiate our thesis, but merely by way of illustration. A physicist exhibiting a model made of wire and wooden balls, representing the relative positions of the protons and electrons of a chlorine atom and their paths of motion, is not trying to prove a theory of matter, but simply endeavoring to illustrate a strongly appealing hypothesis.

[8] A. M. Carr-Saunders, "The Population Problem," p. 477.

[9] The illustrations contained in this paragraph are given more fully in "A Sponge

ant Sunday afternoons are not all occupied by rising young attorneys and plant managers, but often by a clerk from the department store or bank; and painfully, week by week, that clerk is paying something down to an automobile dealer as the price of his meretricious masquerade. At first glance, huge modern wealth seems to have lifted man above the reach of the iron claw of natural selection, but the burden of a towering standard of living bears him down. The family of the modern wage-earner whose wants and worries include theater tickets, a motor car, satin slippers and radio can afford little thought of physical examination or oculist or dentist. Twenty-five per cent. of the children in our large cities go to school every day badly nourished (in New York 34 per cent.), and the parents of many of them own motor cars, radio outfits, fur coats—at least, one of these luxuries.[10]

Had our colony of ants been content with five shot for play and fifteen grains of sugar, the population could have been maintained at fifteen. Had they insisted upon their shot and other gimcracks besides, driving us to cut the ration to five sugar grains, the surviving ants might have lived a well-equipped, civilized, sophisticated life; but survivors would number only five. Our example is absurd? It is not true to ant life? No, but true of man life, where interest is thus divided between desires and needs.

A wren, a mouse, a perch—every living thing but man—has a fixed standard of living; food every so often, crude shelter, perhaps, and nothing further. An increase in sustenance means a like increase in population. But man produces consciously a large part of the food values he consumes, and he insists upon producing and consuming other values as well. (The value of a motor-car, a rather handsome motor-car—that value, in food, would support a workman's family for seven years.) Man's productive energy is divided: part is expended upon the production of food values, and part upon the production of far different values: buildings and clothes, steamships and railways, theaters and parks, telephones and motion pictures, radios and motor-cars, smoking materials and chewing gum. In the proportion that these things enter into the standard of living, by just so much, the tendency of human population to increase as wealth increases is thwarted. Populations, whether of ants or wolves or butterflies or men, tend to increase directly as wealth (weal) increases; but when we speak particularly of man, we must add: population tends to decrease as the standard of living—and with it, the standard of craving—rises.

Though the annual flow of wealth in Great Britain more than equals the total wealth produced each year in China, the population of Great Britain is but forty million, and the population of China, perhaps four hundred million. A vast difference in living-standards explains this striking contrast: the Chinese standard of living is hardly a tenth as high as the British. The population of the United States is one hundred and twenty million; the population of India triples that amount, though India's rate of wealth production is not a third that of the United States. Again, a difference in living-standards will explain. If Americans were to convert into food values the huge flow of wealth which they create, contenting themselves with an East Indian standard of living, population would soon number half a billion—assuming, of course, a revolution in food-producing methods in the United States or in some dark continent with whom we might exchange our manu-

Theory of Population,'' by the present author, *The New Republic*, Vol. XLI, no. 527.

[10] E. B. Reuter, ''Population Problems,'' p. 255.

factured goods—and this assumption is not nearly so bold as the suggestion that an American be content with a standard of living cut a tenth its present dizzy height.

The amount of wealth produced annually in Montana is about equaled in Mississippi: but Mississippi has three times Montana's population. Simply, the standard of living in the southern black belt is very low. Standards of living on the other hand are about the same in Idaho and Kansas; yet Kansas' population is four times that of Idaho. And why? Kansas produces annually far more wealth than does Idaho. If the annual production of wealth in Great Britain increases by 10 per cent., but every family consumes 10 per cent. more in comforts or in luxuries, population must remain the same.[11]

Birth-rates, death-rates, immigration, emigration—all are secondary considerations in the population problem. The piston, piston-rod and crank-shaft of a steam engine are important, but secondary circumstances; the underlying matter is pressure and the expansive force of steam. Controlling factors in the growth of human populations are but two: the rate of wealth production and the standard of living.

Insect, animal, reptile and plant populations vary directly as the means of subsistence increase or decrease. These creatures are not hampered by intelligence and a craving for ever higher living-standards.[12] But with man it is different. In regions where similar living-standards prevail, population varies according to the amount of annually available wealth: in areas that produce equal amounts of wealth, population varies inversely with the height of living-standards.[13]

"What all strive for, even the poorest, is not a living but a way of living."[14] Here is an appealing view which is slowly pervading thought upon the problem of population. A shrewd London stock-broker, a Portuguese-Hebrew by descent, was probably the first person to appreciate in the slightest the bearing of the standard of living upon the size of populations. Says David Ricardo: "The friends of humanity can not but wish that in all countries the laboring classes should have a taste for comforts and enjoyments, and that they should be stimulated by all legal means in their exertions to procure them. *There can not be a better security against a superabundant population.*[15] In these countries where the laboring classes have the fewest wants, and are contented with the cheapest food, the people are exposed to the greatest vicissitudes and miseries."[16] The second clause of our hypothesis, which hazards the guess that population varies inversely with the prevailing standard of living, is simply an acknowledgment that these views are probably correct.

But the second clause of our hypothesis does not merely "emphasize" the standard of living; it asserts that the effect of the struggle for a higher standard of living includes and overreaches the force of the Malthusian checks upon the growth of population. The word

[11] The mathematical turn which our language takes at this point should not be construed as a statement of our hypothesis, but merely as a mathematical illustration of it.

[12] Cf. James Bonar, "Malthus and His Work," pp. 61–2. Cf. "Parallel Chapters from the First and Second Editions of Malthus' Essay on the Principles of Population" (Macmillan Co.), p. 13.

[13] The version of our hypothesis stated here is from a paper in the SCIENTIFIC MONTHLY, July, 1926, 24: 16–18.

[14] R. M. MacIver, University of Toronto, "Civilization and Population," *The New Republic*, December 2, 1925.

[15] Italics are ours.

[16] "Principles of Economics." Chapter V, 2nd edition, p. 95.

emphasized is quoted from an editorial review of the first published statement of our thesis.[17] If our first statement was open to misunderstanding, let us be clearer here. The modern struggle for higher and higher standards of living not only delays marriage and brings restriction of births, it also causes a disregard of the fundamental necessities of life. Not only are all swept into the mad race for civilization's alluring prizes, but the pace has become so furious and attention is so intently centered upon the non-essentials and luxuries of modern life that there is starvation in the midst of plenty. Many persons, whose wages should afford every physical necessity, go undernourished and badly clad to avail themselves of the distinction lent by the latest model this or that, or the elation and thrill to be had from the latest form, or pitch, of amusement. The desirability of a good quality of food and other essentials is by its obviousness thrust into some oubliette of consciousness; while luxuries, which are the more conspicuous for their rarity, are feverishly desired. Undernourishment, exposure and resulting disease are as definitely operative in checking the growth of population as when wealth was far less abundant.

In wording our hypothesis, have we used the term *wealth* correctly? Do we mean wealth or do we mean well-being? Population tends to increase directly with wealth, or, population tends to increase directly with well-being? There is an important difference in import—in part these terms are contradictory. Wealth is a smaller realm within the domain of well-being. Human wealth comprises all items of well-being that exist under scarcity conditions. A clear warrant certainly for our saying that these terms are in large sense contradictory, for only when an item in human well-being becomes inadequate—becomes scarce—is it classed as wealth. That area in the field of well-being not covered by the term wealth comprises items of well-being which do not exist under scarcity conditions, and which therefore can not constitute a limiting, or a controlling, circumstance. We have then chosen our language correctly: Population tends to vary directly with wealth. *Wealth* is our word.

Let us sum up. Over-propagation is universal. Life tends constantly to press upon the conditions of existence. Human life offers no exception. Wealth—all items of human well-being that exist under scarcity conditions—epitomizes the objective limiting circumstances of human existence. But the growth of population has not kept pace with amelioration of the conditions of human existence—population has not increased as fast as wealth. How are we to explain the *slowness* of population growth? The sole difference between the human case and all other cases in population is the progressive inclusion of non-essentials in a rapidly rising standard of living: wealth multiplies rapidly, but it is split into constantly larger shares: a certain increase in wealth therefore does not result in proportionate increase of population. *Marriage is delayed and births are restricted;* furthermore, emphasis is thrown upon non-essential values, and the simple necessities of life are neglected; undernourishment, exposure and resultant disease are consequently kept in play. A rising standard of living—and standard of craving—trims population at both ends: it tends to reduce the birth-rate and works against the reduction of the death-rate. Our hypothesis of the growth of human population therefore should be read: ***Population tends to increase directly with wealth, and inversely with the prevailing level of the standard of living.***

[17] New York *Times*, January 7, 1925, p. 24.

DEAD VERSUS LIVING MEN

By AUSTIN H. CLARK
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PROFESSOR HUXLEY, while insisting on the demonstrable structural similarity between the anthropoid apes and man, maintained that the differences between them are great and significant, and that the relatively slight physical differences are emphasized by the relatively enormous differences in habits and mode of life. He was unwilling to view man simply as a corpse, believing that a true picture of man in his relation to the animal world could be obtained only by giving due consideration to all available comparative characters, both structural and psychological.

But Sir William Flower was strongly antagonistic to this point of view. He maintained that in considering the relationships between man and the animal world the same principles of classification must be used as are applied elsewhere, because zoological classification never has taken into consideration the psychological characteristics which distinguish the subjects of its investigations. He said further that the essential attributes which distinguish man and which give him a perfectly isolated position among living creatures are not to be found in his bodily structure and therefore should either be left entirely out of consideration or have such weight given to them as would remove him completely out of the region of zoological classification. His position was that to profess to classify man as if he were one of the animals, as in all points of the structure and functions of his organs he undoubtedly is, to place him in the class Mammalia and then to allow other considerations to influence our judgment as to the particular position he should occupy is most illogical.

Since Professor Huxley's time the broader concept of man has among biologists been completely superseded by the narrow view-point so well enunciated by Professor Flower.

This narrow view-point has been developed in such a way and to such extremes as to lead to conclusions which in their total disregard of man as man can not but give offense and arouse antagonism.

No one can deny that a detailed comparative knowledge of the structure of any creature is essential to the determination of its position in relation to the other animals.

But those who study animals both in the field and in the laboratory soon become aware of the important fact that no animal form can be properly understood from the facts revealed by the study of its structure and anatomy alone. An animal is something more than the sum total of the organic compounds, the secretions and the deposits that make up its body. There is something in addition to the tangible physical complex represented by its structure and anatomy.

The bodily mechanism of every animal in life is operated and controlled by a mental mechanism which as yet we are unable to explain in terms of physics and of chemistry. In each sort or kind of animal this mental mechanism takes the form of a definite complex peculiar to the species.

These mental complexes are as much a part of the individuality of each species as are the tangible structures of the body. To base our conclusions upon a single set of characters and to dismiss others as irrelevant is simply to confess

our inability to comprehend and to interpret the whole in its true relations.

It sometimes happens that two animal forms when studied as museum specimens are so extremely similar as to be scarcely separable, or even not always separable with certainty, although in life they could not be confused. For instance, when I was living on the island of St. Vincent I was very familiar with two little flycatchers which have quite different habits and a different song. One is found only in little companies in the lowlands in the vicinity of Kingstown, while the other is solitary and lives on the mountain sides. Must we regard these as trivial varieties of the same species, which is the only course possible on the basis of museum material, or shall we take into account the obvious and considerable differences in their habits and their songs and call them different species?

Descriptions of the different breeds of dogs would be considered wholly incomplete without some mention of the mental traits of each. This is because we appraise the dogs on the basis of all the characters which enter into their relations with us. The diverse mental traits of the different breeds, therefore, become a matter of great interest.

But if in the case of dogs we are always careful to consider the mental differences as well as the structural variations more or less peculiar to each of the several breeds, why should we not admit that the habits of all animals should in the same way be considered in connection with their structure? Why should we be so careful as to emphasize the terriers' peculiar propensity for digging, the spaniels' curious love for water and occasional dexterity in catching fish, the stupidity and ferocity of bull-dogs, and all the other canine traits, and then maintain that man in his relation to the apes must be considered wholly, or almost wholly, on the basis of his structure?

How can we acknowledge the importance of the mental differences between the greyhounds and the hounds, between both of these and collies and between all three and bull-dogs, and then deny, or at least minimize, the importance of the mental differences between the orangs and the chimpanzees, between both and the gorillas and between all these and man?

So far as our evidence goes, the use of fire and of tools were human attributes from the very first appearance of mankind. It may be assumed that the same is true of speech and the use of clothing. There is not the slightest evidence that these human attributes were acquired one by one as man departed more and more from an ape-like ancestor.

It so happens that the closest parallel to the activities of man is to be found in the activities of the insects and their allies and not among the vertebrates or backboned animals where we should expect to find it. Furthermore, among the vertebrates the birds as a whole come rather nearer to man in the scope of their mental attributes than do the other mammals, while among the mammals the rodents—rats, mice, beavers and their relatives—are the most similar.

The use of fire and of fashioned tools is confined to man. Certain ants, some reptiles, as the alligator, and certain of those strange birds called megapodes make use of artificial heat of bacterial origin derived from decaying vegetation. But the ignition point is never reached.

Certain digger wasps use little pebbles or little bits of stick to smooth the earth down over a buried victim. The spinning ants build their silk nests by using their grubs which they hold in their jaws and pass back and forth from leaf to leaf. The grubs have silk glands which the adults lack, so that the construction

of silken nests by ants is possible only through a curious system of enforced child labor. There are other cases of the use of tools and implements by insects. But the tools they use are never made by them.

Many insects in their early stages encase their body in a little jacket made of various substances bound together with a web of silken threads. For instance, the caterpillars of the clothes-moths make suits for themselves of hairs cut from ours. The larvae of the caddis-flies make somewhat similar covering out of sticks or sand grains. Very many insects construct an elaborate cocoon, which may be waterproofed inside, wherein the pupal stage is passed.

Many youthful insects cover themselves with the empty skins of their victims or with various foreign substances which they impale upon or entangle among their spines. This may be primarily for the purpose of concealment or deception, but in many cases it seems to be simply for adornment. At any rate, the larva of a lace-winged fly or the caterpillar of an aphid-feeding butterfly draped in dead aphid skins strongly suggests a primitive human draped in furs.

Many insects have highly developed social systems which superficially seem much like those of man, as we see among the ants, wasps, bees and termites. Some of these social insects seem to be able to exchange a considerable range of information, though on principles quite different from human speech.

Some social ants make use of slaves. Others have developed an elaborate form of agriculture. Many make use of other types of insects—aphids, coccids, jassids, membracids and the caterpillars of various lycaenid butterflies—much as we make use of cattle. These they sometimes tend with the very greatest care, building shelters over them or looking after them in various ways and protecting them from their enemies.

Some insects make use of others which are much more powerful than themselves in traveling from place to place. For instance, the young of the oil beetles are transported by the parents or the attendants of their victims.

All insect societies support scavengers and also parasites of various types, most curious of which are other insects which persuade their hosts to feed them.

Chemical processes are extensively used by insects. These are, however, almost entirely concerned with special bodily secretions. There are the various types of silk produced by insect larvae and by spiders; the paper made by wasps; the wax produced by bees, aphids and other insects; sweet substances secreted by aphids and other types; narcotics used to stupefy the prey; antiseptic substances used to protect the eggs, and various kinds of poisons.

But here we become involved with the chief difference, other than structural, between the insects and the vertebrates. In their relations to the world about them the insects are mainly guided by the chemical senses which in us are represented by taste and smell, whereas in the vertebrates the eyes and ears are commonly the main controlling organs, often combined with touch, and smell and taste are relatively unimportant. So the extensive use of chemical processes by insects is quite in line with the largely chemical nature of their external contacts.

The very diverse snares of spiders and of some insect larvae, as the young of some fungus gnats, the various structures—nests, pitfalls, cells and others—built by insects and their often highly complicated tunnelings show an engineering skill and a knowledge of many of the laws of physics which is quite extraordinary.

Among the insects and their relatives each species on issuing from the egg and on entering every stage thereafter is endowed with a knowledge of all branches of science which is detailed and complete so far as concerns its needs at that particular time. At different periods of its existence its knowledge may differ widely, as in the case of those little caterpillars which at first are flower feeders, then enter ant nests and feed on the young ants and finally turn into butterflies, crawl out of the ant nest and fly away.

The only birds to make use of artificial heat are some of the megapodes or brush-turkeys. These scratch together a loose mound of leaves, rubbish and earth, lay their eggs in it and then cover them. The heat arising from the decaying vegetation in this natural incubator furnishes the warmth necessary for the hatching of the eggs. The same procedure is followed by the alligators and the crocodiles. Other kinds of megapodes and the crocodile bird of northern Africa simply bury their eggs in warm sand, like turtles.

In the formation of their nests birds display the most extraordinary skill in the use of fibers, sticks and mud, or in some cases the secretions from their salivary glands. They also show great skill in hewing out holes in the trunks and branches of dead trees, and in burrowing in banks and in the ground. Often extraordinary ingenuity is exhibited in selecting situations for the nests, both when they do the work of making them themselves and when they appropriate the deserted nest or nesting site of some other species. Many nests are very complicated, especially such nests as are entered from the side. Among the most curious are the ingeniously sewn nests of the oriental tailor-birds, the long pendent nests of the cassiques, related to our orioles, and the more or less similar nests of some of the African weaver-birds. Some birds, as certain weaver-birds and a small parrot in Argentina, build community nests, like apartment houses.

Some water-birds build floating nests, like rafts, which may be towed from place to place. The motmots build their nests in the nests of termites, and certain kingfishers in southeastern Asia make their nests in the holes of trees which are tenanted by bees.

Many birds ornament their nests. The common orioles often weave into their pendent nests bits of bright-colored yarn or string; the indigo bird incorporates bits of paper; the crested flycatchers use the cast skins of snakes, and other birds use other objects, such as shells or bright bits of stone or pebbles. One bird in India enlivens the vicinity of its nest with fireflies stuck in the ground.

But it is not only in the formation of their nests that birds show mental traits more or less parallel to those of man. The bower-birds of Australia build curious runs or play-houses which they ornament with bright and conspicuous objects of all sorts and which have no connection with their nests. Many other birds, particularly in the crow family, as ravens, crows, magpies and jays, are very fond of gathering and hoarding bright, conspicuous objects, especially metallic ones. It may perhaps be mentioned that many birds, especially among the parrots, crows and mynahs, can duplicate more or less extensively and correctly the sounds, though not the intent, of human speech. They are the only creatures which are able to do this.

Among the mammals, only the rodents can be compared with birds in the diversity of their mental traits. It may be noticed that all the true rodents have the peculiarity of sitting erect and using their fore paws very much like hands.

Many make rather elaborate nests on or in the ground, in grass or rushes, or among the branches or in holes in trees. The nests of rodents are always entered from the side or from below and are never open above like the nests of many birds. Perhaps the most interesting of the peculiarities of rodents is to be found in the construction of dams by beavers. Another interesting thing is the habit of some types, as the wood-rats and the Norway rat, of accumulating bright, conspicuous objects more or less after the fashion of the crows.

The existence in man, in the insects, in the birds and in the rodents of so many strikingly similar mental traits which are conspicuously absent in the monkeys and the other mammals must have some significance. There must be some basic underlying reason for this curious distribution of corresponding mental attributes. What have these various groups in common wherein they differ from the other creatures inhabiting the land?

Among the insects man-like mental attributes are almost exclusively confined to types in which the young are very different from the adults, either soft, delicate and headless grubs, as in the case of the ants, bees and social, parasitic and predaceous wasps—the mud-daubers, caterpillar-wasps and others—or soft-bodied, worm-like things as the young of caddis-flies and the caterpillars of small, feeble moths and butterflies. But they also occur in the white ants or termites, which are weak and feeble in all stages, and in a few other types. What may be considered the clothing of the insect body—the construction about it of a more or less dense cocoon of silk, of itself alone or used as a binder for other substances—is common to nearly all insects which have an inactive pupal stage.

Among the birds, mental attributes which parallel the human are almost exclusively confined to those types with helpless young which for their upbringing require the attentions of both parents, and among these they are most obvious and marked in the smaller and weaker forms. Birds with active and more or less self-reliant young which are tended by one parent only, large and powerful birds and sea-birds nesting where they are safe from enemies, as a rule show little or no skill in making nests and scorn the use of ornaments.

Weak and helpless young are especially characteristic of the rodents, particularly of the small mouse-like or rat-like rodents in which the man-like mental attributes are particularly to be remarked. The nests of rodents, like the nests of birds, are primarily incubators designed to facilitate the maintenance of a proper temperature. Many rodent nests, as those of various mice, the musk-rats and the squirrels, would seem to be constructed in such a fashion as to create within them through bacterial action a temperature higher than that outside. Whereas among the birds nests are used only for the rearing of the young, many northern rodents pass the winter in them in a state of hibernation.

So a survey of the animal world brings out the extraordinary fact that mental ingenuity is developed to offset some dangerous physical weakness in the animals involved. This physical weakness usually has to do with helpless younger stages, as in the social insects and the birds and rodents, but it may involve the later stages, as the helpless, inactive pupal stage of certain insects, all stages in the termites, and the hibernation period of rodents.

Thus physical weakness in the animal world is offset by the appearance of mental attributes comparable, or at least parallel, to those of man, and the more pronounced the weakness the more man-like do these attributes become.

Have these sporadic and isolated instances of mentality in the insects, birds and rodents any real bearing on the question of the relationships of man?

So far as his structure goes, man is extremely close to the anthropoid apes. There is no denying this. Those who insist on contemplating man solely as a corpse will stop right here. But those who agree with me that in order correctly and properly to understand man in his relation to the living world we must take into account the mental mechanism that controls and guides his body will wish to continue further.

Of the animal world taken as a whole it may be truly said that where the greatest weakness lies, there also lies the greatest strength. No one can deny that at the present time the insects are the most formidable competitors of man. There are more than three times as many different kinds of insects as there are of all other types of animals together. Among the insects by far the most numerous both in species and in individuals are those forms, as the ants, bees, wasps and their allies, beetles, flies and moths, which have weak and feeble worm-like young. They are the most successful and resourceful of the insects. They include the largest as well as the smallest species, but their average size is considerably less than that of other insects.

Among the mammals the dominant type at the present day is the group of rodents, especially the murine or rat-like rodents. Here again we find as the dominant group, most numerous both in species and in individuals, a group including species of which the average size is very small and which have helpless young.

Among the birds the dominant types, most numerous in species and in individuals, are again those of small size with helpless young.

So everywhere we find as the dominant types of animal life, at least on land, those with inherent weaknesses—small feeble bodies and dependent helpless young—which we might assume would imperil their existence. But in these types weakness of body is more than offset by the occurrence of more or less man-like mental alertness and ingenuity. In these types we see foreshadowed here and there, appearing in a curiously disconnected, sporadic and isolated manner, many of the mental attributes of man.

We learn from the study of paleontology that as animal forms increase in size or otherwise become increasingly more and more specialized they become less and less susceptible of change and more and more dependent upon the maintenance of conditions as they are. If conditions change, the giants and the highly specialized creatures disappear and the groups persist through the smaller and more generalized among the included types.

What bearing has all this on the question of the relationships of man?

First of all, let us repeat that man in his structure undeniably is extremely close to the anthropoid or man-like apes. At the same time there are sharp and clean-cut differences between man and any of the apes. Every bone in the body of a man may be at once distinguished from the corresponding bone in the body of any of the apes.

From the physical view-point man is the least efficient of all living creatures. In the first place, his young are helpless for many years and require parental guidance almost to the adult stage.

In the second place, man is the only vertebrate which has a serial family composed of dependent young in all stages of development ranging from newly born to adult or subadult. In all other vertebrates the young, whether as individuals

or in a litter, are always independent of the parents before new young are born. The only parallel to the conditions found in man are the serial broods of the social ants, bees and wasps. In the third place, man lacks the muscular power of the other vertebrates with which he must compete. His feeble body is no match for the powerful bodies of the great grass-feeding mammals or for those of the great cats, wolves and other predaceous creatures. He is relatively slow of foot and is a poor and inexpert climber.

Feeble and frail of body with helpless and dependent young and the further handicap of a serial family, man is the dominant living creature in the world to-day by virtue of his extraordinary mental attributes. These include all those found in all other living things and many more besides. Man must have a mind superior to that of all other living things because he has the maximum number of liabilities to meet.

It is commonly asserted that while the reactions of man are the result of intelligence, those of insects, birds and rodents are due to instinct, and therefore that the two are not comparable. Instinct is defined as "a special innate propensity, in any organized being, but more especially in the lower animals, producing effects which appear to be those of reason and knowledge, but which transcend the general intelligence or experience of the creature." In the Century Dictionary we read further that "instinct is said to be blind—that is, either the end is not consciously recognized by the animal, or the connection of the means with the end is not understood." Intelligence is defined as "discernment or understanding," and as "cultivated understanding."

Now if intelligence is really discernment or understanding, as according to definition it is, it is difficult to see wherein it differs from instinct as displayed by insects, birds and rodents. For instance, the caterpillar and other fossorial wasps display great discernment and understanding in providing for the welfare of their young, which they will never see. Their actions are certainly based upon definite and detailed knowledge of the conditions which must be met. How they acquired that knowledge is wholly unknown to us, but it is indubitable that the knowledge is there. Whether there is reason back of them or not is a matter of opinion. Reason is variously defined, but all definitions of reason are based upon the general idea that reason is a faculty characteristic of and peculiar to man. As a comparative term, therefore, the word reason is quite without meaning. Whether their actions transcend their general intelligence or experience we do not know. We have no measure whatsoever of their general intelligence, and we can not tell how much they may or may not remember from their own larval life.

There is no object in prolonging this discussion. On examining the facts we see that intelligence and reason are supposed to be peculiar to man; actions which in man are acknowledged to be the result of intelligence and reason, such as the use of heat, tools and clothing, if duplicated in insects are assumed to be the result of blind instinct. But in the absence of indubitable proof the same or very similar actions can not be supposed to arise from wholly different causes. So after all we are forced to admit that intelligence and reason are simply mental attributes we think we understand, while instinct is a mental attribute we know we do not understand. That seems to be the only tangible difference between them.

We marvel at the fact that every insect at birth and at the beginning of every subsequent stage thereafter is en-

dowed with a technical education which is entirely sufficient for its needs. This is instinct, we say. Then, putting all ideas of instinct aside, we carefully note the actions of an ape and compare them with those of a child. We find various similarities. Of course we do; it would be quite extraordinary if we did not. Some observers, closing their eyes to a whole series of important facts, say that this proves the close relationship between the apes and man. This relationship is already proved by their structure, so this is nothing new.

But we are not informed that none of the apes or monkeys have a true baby stage, except possibly of the briefest duration. They are born with what might be called a subadult mentality. The actions of the young are almost from the very first more or less like those of the parents. This is not at all the case with children.

In order to show the fundamental and far-reaching differences between babies and young monkeys three peculiarities of babies may be mentioned.

When babies begin to hold and to touch objects they show an extraordinary preference for hard and especially rough objects. Babies are very fond of passing their fingers over sandpaper, which they much prefer to ordinary paper. So far as I know this is not at all true of young monkeys.

Babies when playing with a hard object, such as a watch, always end by whacking it against something. If monkeys lose interest in anything they simply drop it. It may be remarked, however, that adult monkeys, especially baboons, are sometimes extremely destructive. The whacking propensity of babies certainly is not learned from their parents. It commonly results in parental resentment. But it is perhaps the most important and significant instinctive reaction of babies. It at once proclaims them as fundamentally different from monkeys. So does their preference for hard, rough objects. It is probably not too much to say that these two instinctive reactions of babies lie at the base of all material human progress.

A third peculiarity of babies is a constant desire to hold something. Young monkeys, of course, like to cling to the mother, but show no desire to hold foreign objects. This curious desire to have something in the hand is continued throughout life. Women prefer carrying valuables in hand-bags which are easily mislaid to carrying them in pockets where they would be safe and both hands would be free, and very many men feel more or less ill at ease without a cane or newspaper or something else carried in the hand.

It is usually assumed that man is descended from tree-living or arboreal apes. Every zoologist will admit that the apes and monkeys are very highly specialized.

From a study of paleontology we learn that a specialized type of creature either becomes still further specialized or dies out. It never gives rise to less specialized types. It is the least specialized creatures that contain the seeds of the evolutionary trees.

Now if apes and monkeys are highly specialized how could man have descended from them without forming a conspicuous exception to an otherwise fixed and immutable evolutionary law?

Nearly all modern evolutionists maintain that monkeys are primarily tree-living creatures. There is no proof of this whatever. Of course the great majority of the existing monkeys live in trees. But this does not prove monkeys as a whole to be, or rather to have been, fundamentally arboreal animals.

At the present day many kinds of baboons live where there are no trees,

while others, and also some of the macaques, living in sparse or open forests, prefer the ground to the trees. In a rather open forest I once surprised a Barbary ape feeding on the ground which made off through the woods at a terrific rate toward a rocky hill in the distance. Evidently it felt quite safe in the open, but not in a tree. In fact, this monkey and some of its relatives are seldom seen in trees, except when raiding fruit in the early morning.

Another very prevalent idea is that monkeys are primarily tropical creatures adapted to a warm climate. Most of the living monkeys are tropical. But the monkeys of the mountains of Japan, and especially those of the highlands of Tibet, are perfectly well able to endure extremely severe winters. Monkeys will live wherever there is a sufficiency of the right kind of food, regardless of temperature.

Monkeys can be properly appreciated only when considered in connection with the sloths and ant-eaters. The three types of living sloths all live in trees, hanging upside down from the branches. One of the ant-eaters, the well-known great ant-eater, lives on the ground, but all the other ant-eaters are exclusively, or at least chiefly, arboreal.

The sloths and ant-eaters, therefore, at the present time are more emphatically tree-living creatures than are the monkeys. The great ant-eater, like the chimpanzee and the gorilla, seems to have descended from the trees to the ground. He is very poorly adapted for terrestrial existence, for his fore paws are fitted for clinging and tearing, not for walking, and when he walks he supports himself on the knuckles of the fore paws with the fingers turned in just as do the gorilla and the chimpanzee. When cornered he does not make any attempt to run, because his awkward hobbling gait can not be quickened into an effective run. So he faces the enemy and stands erect with his long arms outstretched. The gorilla also faces the enemy, pounding his chest.

It so happens that we know a rather large number of fossil sloths. These are creatures which might be described as combining the body of the great anteater with the head of a sloth. They all had grasping fore feet with long claws and in walking the outer side of the wrist was placed on the ground, and the hand was turned inward.

The ground sloths were far too large and heavy ever to have lived in trees. But the structure of their feet, especially of their fore feet, was such as to make them especially well fitted for climbing, just as in the case of the monkeys. So some of the sloths became arboreal. Eventually all of them except for three small, tree-living types died out.

I can not help believing that the monkeys and the sloths must have had approximately the same history. The monkeys were probably originally terrestrial creatures with grasping fore feet but less specialized hind feet. As in the case of sloths and ant-eaters, tree-living forms were developed reaching their highest perfection in the gibbons and some of the American monkeys—especially in America. It is doubtful if the gorilla and the chimpanzee were ever more arboreal than they are now. While this is pure speculation, it is more reasonable than the assumption that monkeys are fundamentally tree-living creatures.

Man is, of course, one of the Primates, the group which includes man and the monkeys. He is structurally very close to the anthropoid apes, but there are definite, clean-cut and important differences between man and any of the apes. These structural differences are greatly accentuated by other differences which seem to be of a fundamental nature.

The young of man are helpless and pass a considerable time in a baby stage, whereas the young of all monkeys are practically from the first little monkeys. Many instinctive reactions of babies are related to distinctive human traits and are very different from anything seen in young monkeys.

Man has a serial family of more or less helpless young in all stages necessitating the combined care of both parents, or its equivalent, over a long period of years. The serial family is the basis of the human social system, which is wholly different from the horde life of the apes.

Elsewhere in the animal kingdom a serial family of dependent young is found only in the social ants, wasps and bees, which have as a result developed a social system parallel to the human. In the monkeys we find a social life without any social system. The individuals simply live together in a promiscuous horde in which each female raises her own young unaided. The social life of monkeys resembles that of wolves, wild cattle and other creatures, but not that of man.

Man is physically weaker than any of his competitors. But this weakness, accentuated by the dependent family consisting of several or many children in all stages of development, is offset by the existence in man of inherent instincts—foreshadowed here and there in isolated instances in the lower animals but grouped and accentuated in man—such as the use of fashioned tools, of fire, of speech and of clothing.

These inherent instincts have by man himself been coordinated into intelligence, and this intelligence developed until now man is easily supreme. Not only has man been able to excel all other living creatures in their specialties, including rapid transportation over the land and over and through water, flying and burrowing, but he is rapidly mastering the mysteries of the chemical syntheses of plants.

Man never was arboreal, and none of his ancestors was ever arboreal. All his characteristics are those of a ground-living creature walking erect. Man never was a monkey. Man is a mutation, and a rather broad mutation, from the same general stock as that which produced the monkeys. Just what that was we do not know.

A BIOLOGICAL METHOD FOR DESTROYING BEDBUGS

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SEVERAL preparations of known and unknown composition have been tried for the destruction of bedbugs. The results from the use of these preparations, however, are irregular and incomplete. They require persistent use of antiseptic medicines on the spots requiring disinfection—a task and expense varying according to the size of the place to be disinfected.

To-day the proposed method is not limited to the use of antiseptic drugs only. It is a biological method involving no great additional work or expense.

The bedbugs, as we know, belong to the class of semi-winged, of the family of Cimicids, with the name *Cimex lectularius* for the bedbugs of our country, *Cimex rotundatus* for tropical bedbugs, *Cimex hirundinis* for bedbugs of swallows' nests. Several writers have stated that bedbugs are carriers of different diseases, chief of which are: recurrent fever, plague, leprosy, tuberculosis, kala-azar and the American trypanosomiasis; but for the present these remain simply as conjectures until further investigations show whether they are well founded or not. July, 1925, H. E. Shortt and C. S. Swaminath[1] pointed out that bedbugs could not transmit kala-azar to monkeys, although the parasites developed enough in the body of the bedbugs on which they were making their experiments. Disregarding the diseases mentioned above, the nightly disturbance of the parasites is such that many have experienced their bites, especially if one happened to be in a small country hotel or has been in military service. From many people who have come to Greece to study and see the ancient monuments I have heard complaints because of the bites which they have received in various Greek towns. My friend, Stilpon Pittakis, director of the late Museum of the Evangelical College of Smyrna, came to me in desperation, after a sleepless night, and in reply to my question as to the reason for his condition said, "Athens was called famous by the ancients; I call it a city of bedbugs, *Koreopolis.*"

The condition of some of the houses of modern Greece as well as of Albania and other parts of the Balkans has been the same from antiquity. In the "Clouds" of Aristophanes we read this interesting dialogue:

> Socrates: Here Strepsiades, bring me a bed.
> Strepsiades: But I can't. The bedbugs won't let me.

In the "Frogs" of the same author, Dionysus asks Heracles, when he was thinking of going to heaven, "Tell me about it—ports . . . streets, hotels, where bedbugs are most scarce."

In Athens in September, 1922, after the tragic days of our nation, many refugees were established in wooden barracks. Immediately bedbugs were found to such an extent that many of the inhabitants spent the night in destroying these parasites. Unfortunately, the bedbugs multiplied so rapidly that in 1923 many inhabitants of the camp "Kaisariani" during the summer nights moved their beds into the roads or into neighboring fields in the hope of finding a few hours of rest. Unhappily even this was impossible because the bedbugs came

[1] H. E. Shortt and C. S. Swaminath, *Indian Jrl. Med. Research*, July, 1925, 143.

down from the roofs of the camp into the roads and quickly reached the beds of the people; and after a time some members of the family were forced to sweep the floor in order in this way to keep an area clean from the approaching army of bedbugs. This I could not verify myself, but trustworthy inhabitants of the camps reported this state of affairs on several occasions. Such was the condition for two years, 1923, 1924. Then suddenly the bedbugs decreased and gradually disappeared completely, first in the camp "Kaisariani" and then in the others. Probably some thought that this result was due to the cleaning which the inhabitants had undertaken, for they had worked very hard to clean their rooms, using different antiseptics. But we know that disinfection of the wood from such parasites is practically impossible, especially in these wooden barracks where some people succeeded in destroying the parasites, but others, for various reasons, through carelessness or inability to use antiseptic medicines, did not meet with any effective result.

The destruction of the bedbugs came finally and completely, because they were no longer found after 1925 in the camps mentioned above. We examined the various causes, and finally found a special kind of spider which we studied intensively in the laboratory of the American Near East Relief. This is the reason for the destruction of the bedbugs. This spider is in length about one and a half centimeters, in width three quarters of a centimeter, and is made up of the cephalothorax, abdomen and four pairs of legs. It is of light gray color, the dorsal surface of brown with three bands of darker color, one in the middle and one each on the sides, all three curving down to the abdomen.

The movements of this spider are such that one is amazed at the ease with which it seizes not only bedbugs but also flies that happen to fly near it. It feeds especially on the blood of bedbugs, seizing the insects by their backs and sucking their blood to such an extent that finally there is nothing left but the skin.

The bedbug does not appear to be aware of such a dangerous enemy, because it draws near to the spider without fear, and we know, on the contrary, that it tries to save itself when it is pursued by man. When a bedbug draws near to the spider which is already busy with its first prey the spider pricks the second bedbug with its hind legs so that it remains motionless until the spider has finished its first victim. I thought that through these pricks the spider anesthetized its prey by some special kind of poison, but my friend, Mr. Tanagras, to whom I mentioned the actions of the spider, explained this by the phenomenon of catalepsy.

In this way each spider in our laboratory fed upon thirty or forty bedbugs a day, according to their size and to the quantity of blood food. After a few days the female formed a nest of solid, narrow web, about four centimeters square, within which there were found thirty yellow eggs, of the size of the head of a pin. When examined with a microscope they are seen to be disk-shaped, and have a central nucleus of thick, gray matter, while the circular part around it is transparent. After eighteen days the young spiders are hatched in the summer time, and immediately they begin to attack the bedbugs with no fear of their large size, curiously enough. Several young spiders attack the bedbugs upon their backs and suck their blood in the same way as the adult spiders do. Their development takes place quickly, and in about three months they reach a fully mature form, after which they will change their skins several times.

The same spider weaves two or three nests in summer time, and watches over them during the incubation period. I

sent some specimens of this spider to the British Museum of Natural History for further study. To Dr. Louis Sambon, who very courteously examined my specimens and sent me detailed information concerning them and the pitting of natural enemies against carriers of diseases during ancient times, I owe very deep obligations.[2] Dr. Sambon determined that the bedbug-eating spiders belong to the genus Thanatos, subfamily Philodrominae of the family Thomisidae. I sent specimens to Dr. L. O. Howard, the famous entomologist of Washington, D. C., and at his request Dr. Petrunkevitch, of Yale University, very kindly determined the species as *T. flavidus* Simon.

So far as I am aware there is no record in entomological or medical literature of spiders being used to eradicate bedbugs. Dr. Sambon wrote to me:

> Your information concerning the destruction of bedbugs by spiders in the infected wooden barracks allotted to refugees in Athens is of great interest and parallels an observation I made some years ago (1910) in Italy, where in stables of the Province of Bergamo I found similar spiders, preying upon swarms of the stable-fly (*Stomoxys calcitrans*) gorged with the blood of oxen. From time immemorial the Italian peasants have held that cobwebs in stables are essential to the healthiness of cattle and my observations proved them right.[3]

The bedbug-eating spider, although named *Thanatos*, is not poisonous, for the refugees never reported to me any trouble, pain or poisoning due to the spiders. Spiders of the group of Philodrominae are of world-wide distribution and very ancient, as fossil specimens have been found in amber. These active araneids are found usually on grasses, bushes or trees. They probably came to the camps from the neighboring small woods.

Various insects have been mentioned as effective enemies of the bedbug, and their artificial introduction has been suggested as a possible means of control. Among these I may mention the common "kissing or assassin bug" (*Opsicoetes personatus*), the house cockroaches (*Blatta orientalis* and *Blatella germanica*) and the house-ants, especially the tiny red ant (*Monomorium pharaonis*).

Opsicoetes (*Reduvius*) *personatus* was well known to Linnaeus, who wrote "Consumit Cimices Lectularius huius larva, horrida personata." With regard to the cockroach one writer says:

> Previous to our arrival here (St. Helena) in the *Chanticleer*, we had suffered great inconvenience from bedbugs, but the cockroaches no sooner made their appearance than the bugs entirely disappeared. The fact is that the cockroach preys upon them and leaves no vestige or sign of where they have been. So that it is a most valuable insect. . . .[4]

Concerning the little red ant, C. L. Marlatt, of the U. S. Department of Agriculture (1896), writes:

> Mr. Theo. Pergande, of this office, informs me that during the late war, when he was with the Union army, he occupied at one time barracks at Meridian, Mississippi, which had been abandoned by the southern troops some time before. The premises proved to be swarming with bedbugs; but very shortly afterwards the little red house ant discovered the presence of the bedbugs and came in enormous numbers, and Mr. Pergande witnessed the very interesting and pleasing sight of the bedbugs being dismembered or carried away bodily by these very minute ants, many times smaller than the bedbugs which they were handling so successfully. The result was that in a single day the bedbug nuisance was completely abated. And Mr. F. C. M. Boggess from Florida heartily recommends the artificial introduction of the ants to abate this bug nuisance.

Assassin bugs, cockroaches and red ants can hardly be considered as practical factors; Dr. Sambon says that they are as undesirable as the bedbug itself.

[2] L. Sambon, *Jrl. Tropical Medicine*, June, 1924; "Observations and Researches on the Epidemiology of Cancer made in Holland and Italy (May-September, 1925)," August, 1926; "Tropical and Subtropical Diseases," *Journ. Medicine and Hygiene*, June, 1922.

[3] See "Progress Report on the Investigation of Pellagra," *Journal of Trop. Med. and Hyg.*, London, 1910.

[4] Foster's "Voyage," Vol. I, p. 373.

But we can not say the same thing for the spider of the refugee camp, which is not poisonous. These spiders cleaned all the camps at Athens without any other expense. Therefore, I think that their artificial introduction, in military barracks, old houses and in some of the hotels of the Balkans, is to be recommended.

The biological method of the control of injurious insects is well known and has been greatly exploited by the Americans during the last forty years, notably in the introduction of the Australian ladybird, *Novius cardinalis,* to destroy the fluted scale of the orange in California. This method is followed to a somewhat limited extent in America with other introduced pests, and has been adopted in Italy with success in certain instances.

However, Americans were not the first to use such means for guarding against diseases. In reading, we find that our ancestors always used natural enemies as a precaution against different contagious diseases.

Livy points out that in the year 293 B.C. the Romans were afflicted by a plague. By advice of the Sibylline Books they sent an embassy to Epidaurus to seek advice from the priests of Asclepius and to ask for a remedy for the disease. Upon its return the embassy brought to Rome a serpent, which the Romans received and worshiped as a god. The serpent swam from the boat to the island of Tiberius opposite the Capitol—the so-called sacred island where the Romans built a temple to this new god, and for many years thereafter people painted pictures of serpents upon their walls. What was the effect of the serpent in this instance of plague? Was it simply a question of the god who had brought about the end of the epidemic? Professor Sambon, pointing to this example to-day, believes that there are serpents which feed upon mice, the carriers of disease, and that through the destruction of the mice the epidemic also is destroyed. A coin in Pergamum of Lucius Severus (161–169) supports this hypothesis. The coin was struck after a plague; it shows Asclepius holding a serpent in his right hand and a rat in his left. We find other analogies among the Egyptians, who worshiped the scarab because it destroyed worms, and the ibis which fed upon different snails in the Nile. They used to guard themselves from serious diseases, as the hookworm disease and the two Schistosomias.

THE PROCESSION OF FOREIGN INSECT PESTS

By Professor GLENN W. HERRICK

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THE advent of the Mediterranean fruit-fly (*Ceratitis capitata*) into Florida has brought home to the average man in a most forcible manner the serious menace inherent in the possible introduction of a foreign insect. Perhaps no insect pest ever imported into the United States, with the possible exception of the European corn-borer (*Pyrausta nubilalis*), has exerted a more immediate effect on the economic conditions of so large a body of citizens. It is only fair to the fly, however, to say that this effect has not been produced by its own activities or through its own destructiveness, but it has come rather as a result of measures of extermination and quarantine instituted by man himself. It is worth while at this time to reflect upon the foreign insect population of this country—its procession in time, the behavior of certain of its members and its relation to quarantine measures.

From the days of the early colonists foreign insects have been coming into this country in a continuous, persistent procession apparently in spite of any measures taken to prevent them. The following list of the more common older pests and of some of the more recent ones that have come to us from foreign countries will show the continuity of the procession in point of time:

Codling-moth (*Carpocapsa pomonella*), introduced prior to 1750.

Hessian fly (*Phytophaga destructor*), introduced about 1779.

Pear psylla (*Psylla pyricola*), introduced about 1832.

Imported elm-leaf beetle (*Galerucella luteola*), introduced about 1834.

Currant sawfly (*Pteronidea ribesi*), discovered in 1857.

Imported cabbage worm (*Pontia rapae*), introduced about 1860.

Gypsi moth (*Porthetria dispar*), introduced about 1869.

San Jose scale (*Aspidiotus perniciosus*), discovered in 1879.

Larch case-borer (*Coleophora laricella*), discovered in 1886.

Mottled willow borer (*Cryptorhynchus lapathi*), discovered in 1887.

Brown-tail moth (*Euproctis chrysorrhœa*), introduced between 1890 and 1893.

Mexican cotton-boll weevil (*Anthonomus grandis*), introduced in 1892.

Carrot rust fly (*Psila rosae*), discovered in 1901.

Alfalfa weevil (*Phytonomus posticus*), discovered in 1904.

European earwig (*Forficula auricularia*), 1909.

European pine-shoot moth (*Evetria buoliana*), introduced about 1914.

Pine sawfly (*Diprion simile*), discovered in 1914.

Japanese beetle (*Popillia japonica*), discovered in 1916.

Oriental peach moth (*Laspeyresia orientalis*), discovered in 1916.

European corn-borer (*Pyrausta nubilalis*), discovered in 1916.

Tropical fowl mite (*Liponyssus bursa*), discovered in 1916.

Banana-root borer (*Cosmopolitas sordidus*), discovered in 1917.

Pink cotton boll-worm (*Pectinophora gossypiella*), discovered in 1917.

Apple and thorn skeletonizer (*Hemerophila pariana*), discovered in 1917.

Asiatic beetle (*Anomala orientalis*), discovered in 1920.

Satin moth (*Stilpnotia salicis*), discovered in 1920.

Camphor scale (*Pseudaonidia duplex*), discovered in 1920.

Mexican bean beetle (*Epilachna corrupta*), discovered in the east in 1920.

New oriental beetle (*Pseudocneorrhinus setosus*), discovered in 1920.

Australian tomato weevil (*Listroderus obliquus*), discovered in 1922.

Oriental twilight beetle (*Aserica castanea*), discovered in 1921.

Cabbage weevil (*Ceutorhynchus erysimi*), discovered in 1923.

Grape thrips (*Drepanothrips reuteri*), discovered in 1927.

Mexican fruit-fly (*Anastrapha ludens*), discovered in 1927.

Mediterranean fruit-fly (*Ceratitis capitata*), discovered on April 6, 1929.

In pondering this list with its dates of introduction one can scarcely refrain from asking what the stiff quarantine regulations against the vegetable, fruit, cereal and other products of foreign countries instituted some fifteen or more years ago have accomplished in preventing the introduction of undesirable insect visitors. No one can say. Perhaps dozens of unknown dangerous species have been kept out. Two things, however, are certain: namely, that some of the more recent ones which "got by" are now among our most serious pests, and that it is, apparently, very easy for these small animals to enter our country.

On my return from Europe in the autumn of 1926 on the good ship *Orca* I was greatly interested to find on the dining table at breakfast one morning a fine lively female individual of the clover-leaf weevil, a European clover pest which, although it had come to us many years ago, was apparently entering the country again. Whether this tiny weevil had climbed aboard at Cherbourg, France, or at Southampton, England, I had no means of knowing, but there she was, lively and happy, ready, no doubt, to disembark at the pier in New York without any worry concerning quarantine at Ellis Island or the fierce ways of the customs officers in New York and without saying "by your leave" to anybody. She hadn't counted, however, on meeting an entomologist who upset all her plans at once, for now her mortal remains repose on a small black pin in a special case in the writer's collection.

The Migratory Behavior of Some Introduced Insects

It is of considerable interest to examine briefly the behavior of a few of these foreign insects after they become established in this country. The spread of the Mexican cotton-boll weevil is well known and in some respects is significant. A glance at the diagram will show that the weevil spread eastward over the cotton belt, from its center of infestation in Texas, with an irresistible yearly progress despite any state or local quarantine measures instituted against it. The significant aspect of this migration is that the weevil did not jump ahead and form isolated outbreaks here and there, but spread outward in uniform waves passing over all human obstacles.

Fig. 1. A diagram, showing the steady eastward migration of the cotton-boll weevil. Adapted from Hunter and Coad.

The map showing the spread of the Mexican bean beetle in the east after its jump into the middle of Alabama exhibits a similar, steady, irresistible wavelike migration from year to year without sporadic outbreaks in advance (Fig. 2).

FIG. 2. MAP INDICATING THE YEARLY SPREAD OF THE MEXICAN BEAN BEETLE FROM ITS CENTER IN ALABAMA. AFTER N. HOWARD.

The gradual migration of the European corn-borer from its centers of infestation in New York and Canada presents a similar behavior—with no sporadic outbreaks ahead of the general wave-like spread of the moth (Fig. 3).

The Japanese beetle (*Popillia japonica*) is behaving in a similar manner, spreading outward from its original area in eastern Pennsylvania at about an annual average rate of from fifteen to twenty miles. It will probably travel somewhat faster as it gathers momentum during the coming years.

A careful, thoughtful consideration of the migratory habits of such active winged forms as the foregoing species certainly moves one to question the justification for the rigid quarantine measures placed over the areas infested by such insects. These measures are always annoying, always sources of friction and in many cases cause serious losses, if not ruin to individual growers. Besides, the maintenance of the quarantines entails a heavy expense which, of course, falls as taxes upon the people whom they injure as well as upon those whom they are supposed to benefit. The problems connected with the introduction and dispersion in this country of these imported pests should certainly be studied from

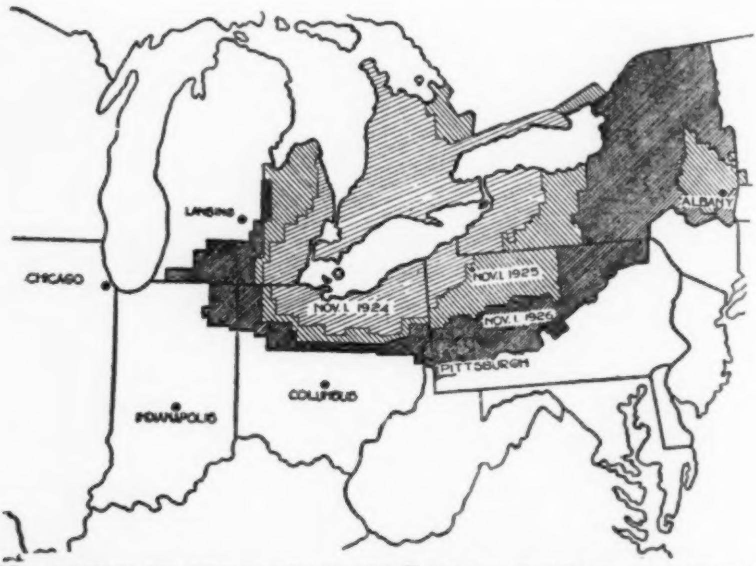

FIG. 3. MAP SHOWING THE DISTRIBUTION OF THE EUROPEAN CORN-BORER AS KNOWN NOVEMBER 1, 1926. THE OUTSIDE (DARKLY SHADED AREA) INDICATES THE SPREAD OF THE PEST WHICH IS BELIEVED TO HAVE OCCURRED DURING THE SUMMER OF 1926. (INFESTED AREA IN NEW ENGLAND NOT SHOWN.) AFTER CAFFREY AND WORTHALER.

all angles and attacked in a broad, constructive manner helpful to all the interests involved as far as possible.

There is, however, another class of insects which demands further consideration. I refer to those which are fixed to some host plant during the greater part of their lives and are practically restricted in their migratory movements to the wanderings of their hosts. The scale insects are the most important members of this group and perhaps the San Jose scale is the most notable example. The San Jose scale has undoubtedly been carried around the world on its host plants in commercial shipments of nursery stock. It jumped from California to Missouri and thence to the eastern seaboard, probably on plum stock shipped from one nursery to another. From these early centers of infestation the insect has been carried all over this country on infested nursery stock. Reasonable quarantine and inspection measures instituted for nursery stock seem to me to be wise, sane and justifiable, and every honest successful nurseryman recognizes the advantages to his business of growing and distributing clean stock.

California has probably been the most active state in the union in maintaining rigid quarantine measures against the introduction of foreign insect pests. Moreover, she has probably obtained the greatest success in excluding these unwelcome guests not because her officials have been wiser, more active or more efficient than the officials of other states but rather because of her advantageous situation. California constitutes a comparatively narrow strip of land extending north and south and bordered on the west by a great water barrier and on the east by an almost impassable land barrier of desert and high mountains. Such a situation constitutes an ideal area for protection against foreign insect foes because it is feasible to guard rather effectively the few points of entry into the state, namely, the few seaports along the Pacific coast and the few passes through

the desert and mountains on the east. Even with these advantages California has not altogether escaped her foreign foes and can not hope to remain untouched in the future, although her invasions will come more slowly but scarcely the less surely.

The Mediterranean fruit-fly has emphasized the whole problem of the invasion of our country by foreign pests and has raised many puzzling questions concerning methods of dealing with so serious a guest. Any statements the writer may make regarding this insect are made with great hesitation, because we do not have extensive knowledge of the habits and activities of the fly and can only guess at its future behavior in this country. Some phases, however, of its activities as a pest of fruits in Europe and in the Hawaiian Islands have been described in some detail by dependable observers.

In the Mediterranean countries in which the fly is present the principal citrus fruits are being produced apparently in paying quantities. In South Africa the fly is not considered a serious pest of citrus fruits. It is, however, very injurious to deciduous fruits, particularly peaches and apricots, but can apparently be controlled on these fruits by using a poison bait if the wild host fruits in the vicinity are destroyed. In Hawaii the fly is a serious pest, particularly in villages, but the conditions in those islands are peculiarly and most favorably suited to the development and multiplication of the insect. Comparable conditions are scarcely to be found anywhere in this country.

Again, the lemon is practically immune to the attacks of the fly. The orange is more subject to the egg-laying of the fly but does not appear to be seriously infested by the maggots in the pulp if the fruits are not allowed to remain on the tree until they become overripe. Investigators speak of the "wonderful resistant power of the oranges to fruit-fly attack." The sour orange appears more susceptible than the sweet ones. Grapefruit are also "particularly resistant to attack up to the time when they are fit for table use." These statements regarding lemons, oranges and grapefruit are founded on studies of the fly made by careful investigators in Hawaii where the conditions are particularly favorable for the insect.

On the other hand, the fly, under some conditions at least, is a most serious pest of other fruits, especially of peaches, plums, pears and apples when these fruits are grown in warm or subtropical climates. Apropos of this phase of the activities of the fly the following quotation from well-known entomologists who have been in intimate contact with the fly is of great interest.

> At 50° F. little if any development takes place, and freezing temperatures can be withstood successfully only for short periods. Accumulated data indicate that the Mediterranean fruit-fly will not become a serious pest in climates where the mean temperature is below 50° F., during periods covering three months of the year.

In the light of this statement it is important to examine the mean temperatures of Georgia, the first great peach-growing territory north of Florida. A cursory examination of the temperatures for the middle section of Georgia including the peach-growing area about Fort Valley shows that the normal mean temperature for December is about 45° F., for January about 44° F. and for February about 45° F. Moreover, the minimum temperatures for this region during December, 1908, for example, varied from 24° to 31° F., during January from 11° to 25° F., while during February they varied from 15° to 23° F. Thus over most of the middle section of Georgia the normal mean temperature is well below 50° F. and there seem to be freezing temperatures at vary-

ing intervals during at least three months of the year. Judging from the meager data at hand it would appear that the fly would be killed during the winter in the middle and northern parts of Georgia and in order to infest the peach crop of any particular year would have to re-enter the state from centers of infestation farther south. It is pertinent to inquire whether the fly when subject to extermination once a year in a given region could ever become a pest of prime importance in that region.

One more quotation from the investigators who were quoted above is worthy of consideration. The studies of these men in the Hawaiian Islands lead them to make the following comment:

> While Hawaiian conditions are unfavorable to the use of poison sprays, the work of the writers has convinced them that these sprays can be employed as successfully in combating this pest in commercial orchards of California and of the southern states, should they ever become infested, as in Africa and Australia.

This is a most hopeful statement and from my experience in combating the cherry and apple fruit-flies, close relatives of the Mediterranean fly, I believe it is a sane and reasonable one.

THE DISCOVERY OF A NEW ANTHROPOID APE IN SOUTH AMERICA?

By Dr. FRANCIS M. ASHLEY-MONTAGU

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THE discovery of new monkeys or apes, apart from their importance, is always of the greatest interest. Not alone do such discoveries provide systematists, anthropologists and other scientists concerned with the study of the Primates—the order of mammals to which man belongs—with much pleasurable labor, but that great public which is interested in the past and future evolution of man, and which attentively follows the newest developments in the fields of spiritual and physical humanism, is ever stirred to the most wholesome enthusiasm on such occasions.

On the eleventh of March, 1929, Dr. George Montandon, of the Muséum National d'Histoire Naturelle, Paris (a well-known anthropologist, and the author of an ingenious theory, the Ologenic theory of anthropogenesis, which holds that the anthropoids and man originated independently over the whole of the earth), announced to the scientific world the discovery of a new and hitherto unknown anthropoid ape.[1] This announcement in itself was sufficient to engender the liveliest interest among scientists. When, however, it was learned that this ape was discovered in South America, a continent in which anthropoids were hitherto completely unknown and in which it was considered extremely unlikely that they should exist, the find took on the dimensions of an epoch-making discovery.

Dr. Francis de Loys, the discoverer of this Primate, and Dr. George Montandon, who was entrusted with the task of presenting the facts to the scientific world, have been kind enough to send me the material upon which this paper is based, and I wish here to express my cordial thanks to them. The facts are as follows.

Dr. de Loys, a geologist, was exploring in the neighborhood of the Tarra River, an affluent of the Rio Catatumbo, in the Motilones districts of Venezuela and Colombia, at a bend of a western minor affluent of the Tarra River, when two huge monkeys, one male, the other female, suddenly broke out upon the exploring party, which was then at rest. Owing to the violence of their attitude, the animals had to be received at the point of the rifle. One of the two was instantly shot dead at very close range, the other, which was unfortunately wounded, managed to get away in the thick growth of the jungle and make good its escape.

The dead animal, which was found to be an adult female, was immediately set up on a box and photographed, certain measurements were then taken, the animal was skinned and its bones cleaned. The subsequent hardships encountered by the party on their long and hazardous journey across the forest unfortunately prevented the final preservation of either the skin or the bones.

When measured, the height of the animal was found to be 157 cms (approximately five feet two inches), and its weight was roughly estimated to be somewhat over eight stone (say 115 pounds). The body, which was entirely covered with a thick coat of coarse, long, grayish-brown hair, was, according to Dr. de Loys, entirely devoid of any trace of a tail. "The jaw, carefully

[1] *Comptes Rendus* des Séances de L'Académie des Sciences, March 11, 1929.

FIG. 1. THE ANIMAL IMMEDIATELY AFTER IT HAD BEEN SHOT

examined, revealed the presence of thirty-two teeth only, without on the back portion of the mandible, any protuberances hinting at the possibility of a greater number of embryonic molar teeth."[2]

All these features, "size, absence of tail, number of teeth and ground habits, together with the strongly humanoid aspect of the face and the ruggedness of the build," lead Dr. de Loys to believe that this creature is a hitherto unknown anthropoid ape.

The two photographs which I am here able to reproduce by the courtesy of Dr. de Loys should convey a good idea of the creature. The object depending from the puberal region between the legs, and which looks like a male copulatory organ, is, in fact, the enormously enlarged clitoris, which, possibly owing to a local hyperemia, corresponding in the male to a condition known as priapism, has been forced out of the vagina. Whatever its cause may be, it is none the less an extraordinary phenomenon.

Careful inspection of these photographs reveals the following facts:

(1) The human-like rounded head presents (*a*) a prominent forehead, and (*b*) there are no markedly overhanging brow-ridges; the nose is wide and presents a broad septum between the outwardly deflected nostrils—characters which are peculiar to the New World monkeys generally, and specifically to the genus *Ateles*.

It is a curious fact that none of the Old World monkeys and apes possesses a forehead as prominent as that found in many New World monkeys. The high forehead, which is so distinctively human a characteristic, is primarily what lends so human an appearance to the head of this creature, whose face is identical in

[2] *The Illustrated London News*, June 15, 1929.

appearance with most species of the genus *Ateles*. In no Old World monkey and in no ape, however, are the nostrils separated by a wide septum, nor are the nostrils so flaring and deflected in an outward and upward direction—this condition is peculiarly South American, there being only three New World genera in which there is an approximation to the Old World arrangement of a narrow septum and inwardly directed nostrils, namely, *Alouatta*, *Aotus* and *Brachyteles*.

(2) With the aid of a magnifying glass one may perceive that the thumb is a much reduced, nail-less tubercle, the merest excrescence upon the side of the hand. This is a characteristic which is specifically associated with *Ateles*, for no other South American monkey possesses so reduced a thumb. None of the Old World monkeys and apes possesses such a character; in only the Orang-Utan, in which the thumb is the most reduced but is quite large compared with this creature's, is the thumb occasionally lacking in a nail. It is clear enough from the photograph that this creature's hands are adapted to an extreme arboreal existence.

(3) The feet are evidently of the quadrupedal grasping type, normally associated with an arboreal life. Doubtless, this creature could support itself on its hind legs, but the structure of its foot renders it quite impossible that its habitual gait is bipedal rather than quadrupedal, or that it spends more time upon the ground than in the trees. This foot is identical in appearance with that of *Ateles*.

(4) The fact that the body was entirely devoid of any trace of a tail (an appendage which is possessed by all South American monkeys) would certainly convince us that we are here dealing with a new species of monkey, but, unfortunately, we can not quite eliminate the possibility of this particular creature having lost its tail in early infancy, thus accounting for there not being even the "trace of a tail." Monkeys have often been known to bite off the tail of some other monkey, the males not infrequently injuring their young in this way. There are, however, a number of other ways in which it is possible to explain the loss of the caudal element in any monkey, but with them we need not concern ourselves here.

(5) Dr. de Loys is quite convinced that the jaw held only thirty-two teeth—a number associated with the Old World Primates and man only. Dr. de Loys does not, however, give the formula for these teeth. In the New World monkeys the formula is $\frac{\text{M3, PM3, C1, I2}}{\text{M3, PM3, C1, I2}}$, that is, three molars, three premolars, one canine and two incisors, for each half of the jaw, in all, thirty-six teeth. The Old World monkeys have lost one premolar in each half of the jaw, thus they possess thirty-two teeth only. If the creature we are here dealing with has lost a premolar, is it not curious that Dr. de Loys should have looked for it on the back portion of the mandible, where only the true molars grow? The bare statement that the jaw held only thirty-two teeth conveys very little to us, for such a statement may mean either that there were only two premolars, or that there were three premolars and two molars (the third having failed to erupt, or to develop), and how are we to decide which is true? The latter condition is the most unlikely one, so that we must provisionally accept the former as the true one.

(6) As far as the stature is concerned, I am not aware of any South American monkey which reaches a height of more than 90 cms (three feet), although this height may conceivably be exceeded in some cases. Certain it is that the height of five feet two inches and the weight of 115 pounds of this monkey are quite un-

FIG. 2. ENLARGEMENT OF THE HEAD

known in any South American monkey. Nor would it appear from an examination of the photographs that these features are due to any anomalous or pathological causes, although such a possibility can not be altogether eliminated. Assuming, however, that there does exist a species of monkey of which that figured here is a normal representative in the matter of height and weight, it becomes certain that we are here dealing with at least a new subspecies of monkey.

The only characters, then, which distinguish this creature from all other South American monkeys are (1) the absence of a tail, (2) the presence of only thirty-two teeth, (3) its height and weight. The number of teeth alone is a character sufficient to justify the creation of a new genus to receive this animal; the absence of a tail, and the height and weight present ancillary reasons for such a procedure but these features are quite insufficient to justify the appellation of *Anthropoid* which has been ap-

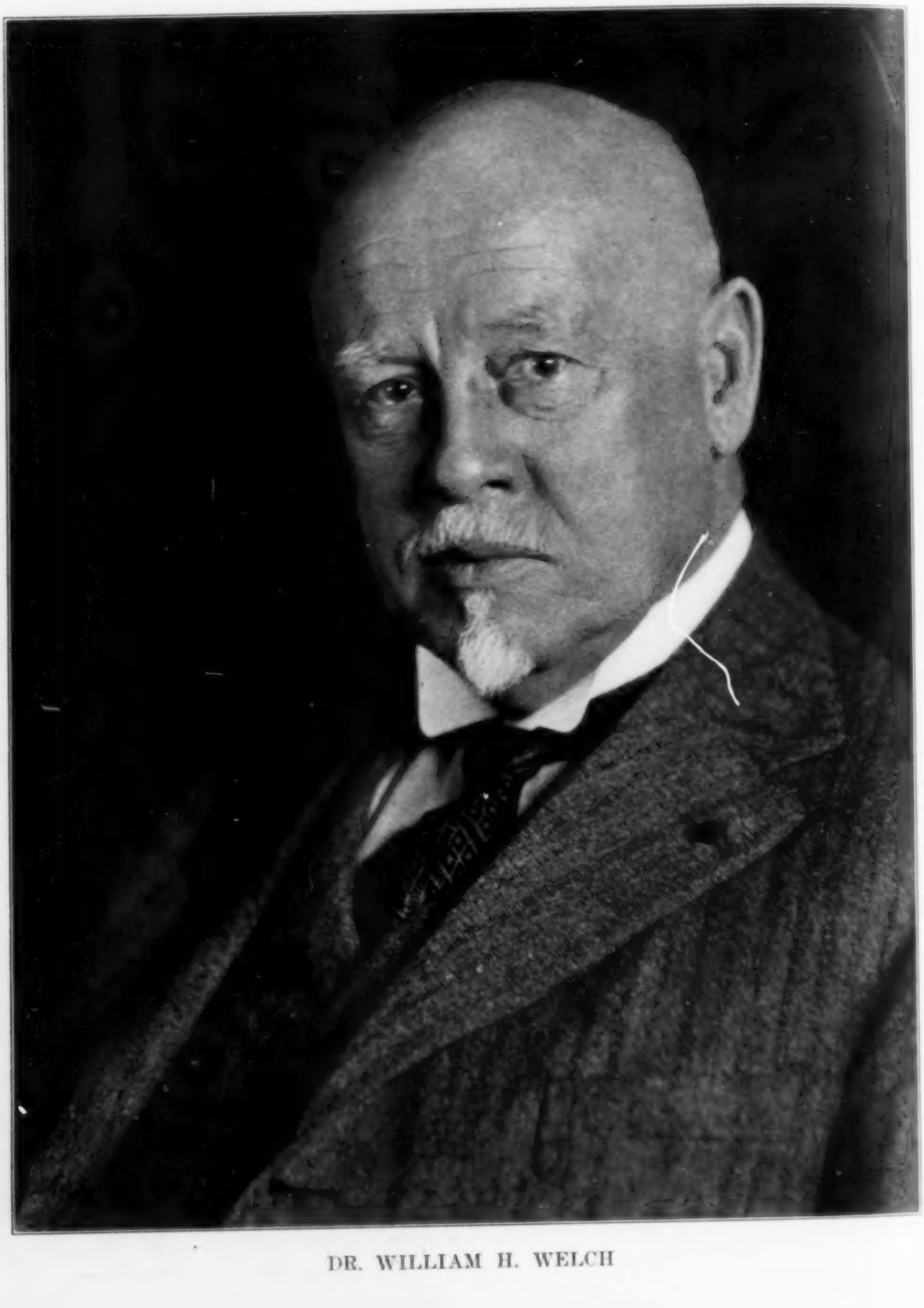
plied to it by Dr. Montandon. Dr. Montandon creates a new genus (as he calls it, but which is really a new sub-family), ***Amer-anthropoidés***, comprising the single species (***Loysi***), whilst reserving the possibility, however, of this being a new species of the genus *Ateles*.

Now exceptional weight and height can at best be regarded as subspecific characters. The absence of a tail in any New World monkey would endow it with specific, but not with generic rank, whilst the loss of a premolar would serve to separate it from all other New World Primates. Neither taillessness nor the loss of a premolar would, however, distinguish this creature, in these respects, from those monkeys of the eastern hemisphere which lack tails. Since, as far as we know, no Old World monkey attains a height of 175 cms nor a weight of 115 pounds, it seems that Dr. Montandon has seen in this (on the basis of its taillessness and its dentition), an adequate reason for endowing this creature with the rank of an anthropoid. That is to say, he has converted a subspecific into a generic character having a sub-family rank, a procedure which is quite unjustified by the facts, and contrary to any natural system of classification.

The most, I think, we can say of this creature is that it is a new genus of monkey, possibly an aberrant type, but at any rate, a close relative to *Ateles*.

It is to be deeply regretted that Dr. de Loys was unable to make a number of photographic records of the skull and other bones; doubtless he little thought of the contingency of losing the actual bones. If a photograph had been made in this case of the skull and the teeth alone, we would have been saved a considerable amount of trouble in speculating about the possibility of this being a new genus of monkey or not; as it is, we have only the observation of Dr. de Loys to rely upon, which, even if he were the most accomplished observer in the world, is not sufficient to satisfy scientific standards of accuracy.

It has ever been the custom to deride the new discovery of apes—the classic case of Du Chaillu and the gorilla is yet fresh within living memory (1859–65), whilst the story of the acrimonious battles which have raged over the discovery of the remains of extinct races of man is too well known to require any amplification here. Let us here bear these events in mind, and endeavor not to commit a like injustice; let us also, however, be cautious, lest in our anxiety to be just we grant too much, and say, until further *real* evidence is forthcoming, the only attitude to adopt in this matter is that of suspended judgment.



DR. WILLIAM H. WELCH

THE PROGRESS OF SCIENCE

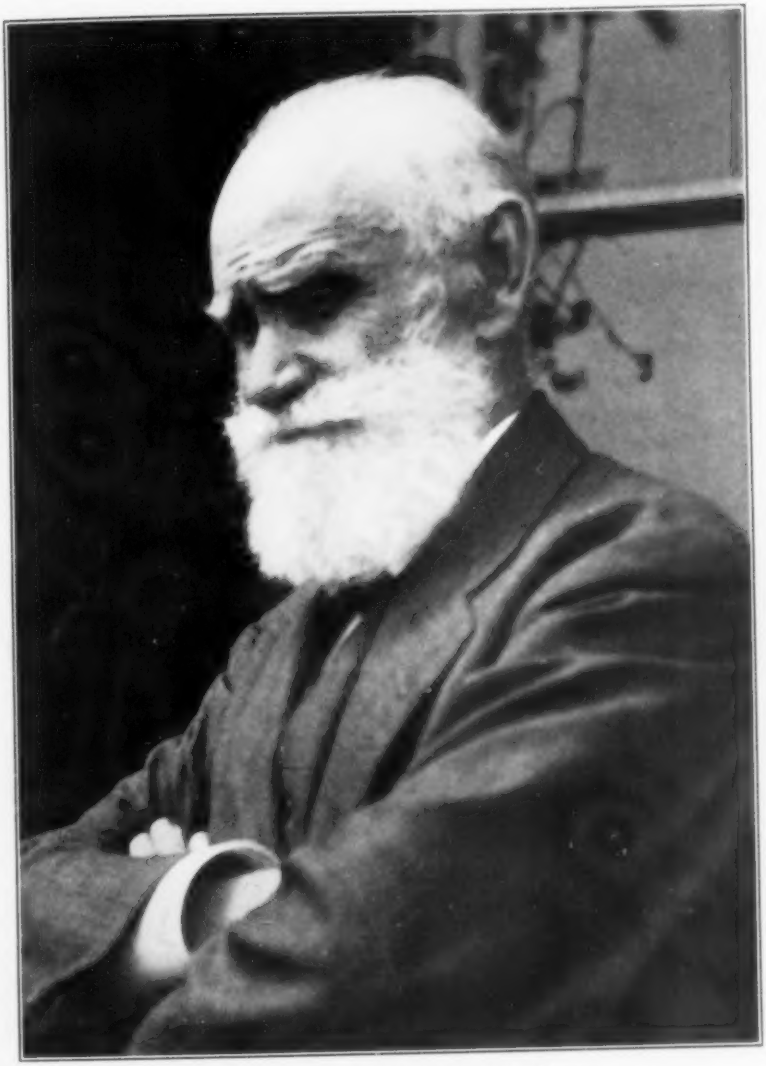
THE WILLIAM H. WELCH MEDICAL LIBRARY AND THE DEPARTMENT OF THE HISTORY OF MEDICINE OF THE JOHNS HOPKINS UNIVERSITY

On Thursday and Friday, October 17 and 18, the William H. Welch Medical Library and the new Department of the History of Medicine of the Johns Hopkins University will be opened with appropriate exercises. Both the Welch Medical Library and the Department of the History of Medicine have been under consideration by the Johns Hopkins University for some years and their establishment may be said to mark the fulfillment of plans made with the opening of the Johns Hopkins Hospital and School of Medicine. At that time a historical club was organized, chiefly through the activity and interest of Dr. Welch and Dr. Osler, ably seconded by Dr. Kelly and Dr. Halstead. From time to time lectures on the history of medicine were given in the medical school but the historical club continued for many years as the chief center of interest for those to whom the historical aspect of medicine especially appealed. The final establishment of the Department of the History of Medicine, however, is closely bound up with the career of Dr. Welch. Called from Bellevue Hospital Medical College in 1884 to become Baxley professor of pathology in the Johns Hopkins University, after a distinguished career in New York City, Dr. Welch organized a modern institute of pathology in Baltimore in which numerous talented young men and women have been trained in pathological anatomy and in bacteriology, especially in the bacteriology of the infectious diseases. In 1916 Dr. Welch retired from the chair of pathology, his successor being one of his own pupils, Dr. W. G. MacCallum, professor of pathology in Columbia University, New York, and undertook the organization of the new school of hygiene and public health, made possible to the Johns Hopkins University by the generosity of the General Education Board. At the same time Dr. Welch was busily engaged in the United States Army, as a member of its medical corps. In 1926 Dr. Welch resigned from the directorship of the school of hygiene and public health to become professor of the history of medicine in the medical school, his place as director being filled by the present incumbent, Dr. W. H. Howell. This professorship in the history of medicine is the first full-time professorship in this subject in America, and there are but two or three completely endowed institutes of medical history in Europe. The Johns Hopkins University is indeed fortunate in securing Dr. Welch for this post, since he combines in an unusual degree a complete training in the medical sciences with a profound knowledge of their history.

About the time that the professorship in the history of medicine was established, the necessary funds were secured from the General Education Board and from unnamed and generous donors for the construction and endowment of a medical library to house the collections of books and journals in the libraries of the Johns Hopkins Hospital, School of Medicine and School of Hygiene and Public Health. Very appropriately this medical library has been named after Dr. Welch who has been so long identified with the three institutions which it will serve. Mr. E. L. Tilton, of New York, an authority on the architecture of libraries, was asked to plan the library building which was completed in November, 1928, the three constituent libraries

THE WILLIAM H. WELCH MEDICAL LIBRARY

being transferred to it within a short time. The Welch Library building merits somewhat more extended notice than is here possible. In brief, it consists of three floors of which the ground floor is devoted to the offices of the library personnel and to rooms for cataloguing and binding books. On the second floor is a large corridor in the center with a reading room at one end and a reception hall, the Great Hall as it will be called, at the other. The reading room is large enough to accommodate about a hundred readers and connects directly with the stacks. The Great Hall is especially designed for receptions and conferences. The decorations of this room have been executed by Mr. Lascari, of New York, and in it has been placed Sargent's portrait of the four doctors, Dr. Welch, Dr. Osler, Dr. Halstead and Dr. Kelly, which has hitherto been hung in Gilman Hall at Homewood. On the third floor are about a dozen rooms for the Department of the History of Medicine, offices, lecture rooms, conference rooms and a number of small studies for members of the staff. The back part of the building contains the stacks for books, eight tiers in height, with a large number of small cubicles for individual workers. The stacks are large enough to hold several hundred thousand volumes and are of course at present only partially occupied. The hospital library, which was begun with the opening of the hospital, contained about 25,000 books and journals, dealing chiefly with the clinical branches of medicine, the library of the school of medicine, about 15,000 volumes, dealing principally with the underlying medical sciences and the library of the school of hygiene about 10,000 books concerning hygiene and public health. In addition to these 50,000 volumes are a considerable number of special collections which have been presented to the library by its



PROFESSOR IVAN PAVLOV

OF THE UNIVERSITY OF LENINGRAD, WHO WILL CELEBRATE HIS EIGHTIETH BIRTHDAY ON SEPTEMBER 22 IN THE UNITED STATES, WHERE HE HAS COME TO ATTEND THE INTERNATIONAL CONGRESSES OF PHYSIOLOGY AND PSYCHOLOGY.

DR. CH. NICOLLE

DIRECTOR OF THE PASTEUR INSTITUTE AT TUNIS, TO WHOM A NOBEL PRIZE IN MEDICINE HAS BEEN AWARDED IN CONSIDERATION OF HIS WORK ON TYPHUS, MORE ESPECIALLY ON THE PART PLAYED BY LICE IN CARRYING THE DISEASE.

friends and which will gradually be amalgamated with it. Among these contributors may be mentioned especially Dr. Kelly and Dr. Young who have donated a number of rare and valuable books dealing with medical history. The libraries of the late Dr. Halstead and the late Dr. Hurd have also been bequeathed to the university and will be cared for in the Welch Library. Finally, Dr. Welch spent a long period of time abroad, while the library building was under construction, gathering books in medical history from various sources in Europe, especially in London, Paris and Amsterdam. The library starts, therefore, with well over 75,000 volumes and it is anticipated that several thousand accessions will be made each year.

On Thursday the Welch Medical Library will be formally dedicated at 11 o'clock at which time it is expected that Dr. Harvey Cushing, of Harvard University, will make the principal address. The afternoon will be given up to a conference on medical libraries and in the evening there will be a large public reception for the inspection of the library building. On Friday the Department of the History of Medicine will be inaugurated. Dr. Welch will preside and outline his plans for the organization and development of the department. The address on this occasion will be given by Professor Karl Sudhoff, of the University of Leipzig. The afternoon will be devoted to a conference on the history of medicine and to an exhibition of the Harvey Terecentenary Film. Friday evening will be reserved for private entertainments and dinners. It is hoped that many of the graduates of the university, former house officers of the hospital and the numerous friends of Dr. Welch will make the dedication of the library named in his honor and the inauguration of this new department in the university which he will head, the occasion of a visit to Baltimore.

THE PHYSIOLOGICAL EFFECTS OF SUPER-SONIC WAVES

A "DEATH WHISPER," which causes matter within living cells to whirl to destruction without injuring the cell walls, has been produced in experiments conducted jointly by Dr. E. Newton Harvey, professor of physiology at Princeton University, and Alfred E. Loomis, of the Loomis Laboratory, of Tuxedo Park, N. Y. This dance of death within the cell is caused by supersonic waves which oscillate twenty times as rapidly as those which can be heard by the human ear.

Chloroplasts within the cells of living plants are forced from their usual positions by these super-sonic waves and are driven at high speed in miniature whirlpools about the center of the cell.

Under a high-power microscope it is possible to follow the progressive destruction of blood corpuscles of a frog. The oval cells at first become warped and twisted. Strained areas appear and the color fades, leaving a pale distorted shadow. Human corpuscles are likewise twisted and sometimes broken up into many small globules, like an emulsion of oil.

The super-sonic waves are produced by a miniature radio broadcasting apparatus which causes a quartz crystal to vibrate. The apparatus is operated on 110 volt alternating current and employs a 75-watt tube with two small transformers. The apparatus has been so devised that the quartz crystal, the producer of the super-sonic waves, can be placed on the stage of a microscope with the specimen to be studied above it in the direct path of the waves. In

TRIBUTES TO
DR. DAVID STARR JORDAN

IN THE PHOTOGRAPH BY BURT DAVIS, DR. JORDAN, CHANCELLOR EMERITUS OF STANFORD UNIVERSITY, IS SHOWN IN HIS GARDEN IN PALO ALTO WITH A GIFT SENT HIM BY STANFORD GRADUATES IN TOKYO TO MARK HIS EFFORTS FOR WORLD UNITY AND PEACE. IT IS MAINLY OF BRONZE WITH GOLD AND SILVER OVERLAYS, AND CONSISTS OF THE FIGURE OF A DOVE PERCHED ON A BROKEN TEMPLE ROOF. BELOW IS A PLAQUE OF DR. JORDAN BY CARLETON B. ANGELL, WHICH WILL BE HUNG IN THE HALL OF THE NEW MUSEUM BUILDING OF THE UNIVERSITY OF MICHIGAN. WE OWE THE ILLUSTRATIONS TO THE COURTESY OF *The Stanford Illustrated Review.*

this way it has been possible for the first time to examine the effect of the "death whisper" upon microscopic cells. By governing the intensity of the waves, the whirling or mixing of the matter within the cells can be accurately controlled.

Professor Harvey, who has been working for a number of years as well upon the production of "cold light," refused to predict what effect the study of the properties of super-sonic waves might have upon the medical science of the future. At present experiments are being conducted to find out what effect the mixing of organ-forming substances within the eggs of marine life will have upon the young which develop from them.

The microscopic method is said by Dr. Harvey to offer a promising means of attack upon the problem of influencing the development of eggs of various species, as forces can thus be applied inside an egg at different stages of its development without the necessity of puncturing the cell wall or enveloping membrane. The results suggest the interesting possibility of converting an egg with determinate cleavage into an indeterminate one by thoroughly mixing and redistributing the organ-forming substances of its interior. He is now engaged upon this and allied problems. No effects of the waves have been noted that could be clearly traced to an influence on chemical processes in cells. The phenomena in living organisms, apart from temperature rise, are connected with mechanical effects, the most striking of which might be best described as "intracellular stirring."

Mr. Loomis, who is a physicist, perfected the new microscopic apparatus for the production of the super-sonic waves, while Dr. Harvey has been studying the effect of them upon cells from the physiological standpoint.

EFFECT OF ACTIVITY AND FOOD ON BLOOD CONSTITUENTS

THAT food, especially protein food, causes an increase in the number of leucocytes in the circulating blood has been quite generally accepted as a fact since first reported by Moleschott in 1854. In the 1927 edition of Dorland's "Medical Dictionary" it is stated that leucocytosis "occurs normally during digestion." In view of these circumstances the recent work of Dr. Walter E. Garrey, professor of physiology at the Vanderbilt University School of Medicine, is of especial interest. In his experiments he finds that even a meal selected particularly for its high protein content causes no alteration in the number of white blood cells in the circulatory system. He believes that other opinions in this matter fall short of proof because the conditions under which the leucocyte counts were made fail to exclude the effects of factors which in his experience cause continuous variations in the number of circulating leucocytes. These variations become evident when successive counts are made; they may amount to several hundred per cent. depending upon the activity of the subject. The more careful the technique, the more certainly will these variations appear and reflect the physiological activity of the individual. They disappear, however, if the subject is placed in a recumbent posture and remains physically and mentally in a condition of rest. Furthermore, in about an hour of this recumbent rest the leucocyte count will have fallen to its lowest physiological level, a level which is practically as low as that before rising from a night's sleep. This level is maintained with surprising constancy and is referred to as the *basal level*, and in general is between 5,000 and 6,000 leuco-

cytes per cubic millimeter of blood. This is in striking contrast to the activity level of 9,000 or 10,000 usually found in laboratory workers or other individuals going about their ordinary activities.

The "basal level," then, is a condition with which one may compare other states and by this reference determine the effects of any single variable which may affect the leucocyte count. Dr. Garrey finds that his extensive data indicate conclusively that the ordinary morning meal had no apparent effect upon the activity level of subjects when they presented themselves at the laboratory, but more significant was the fact that when these subjects assumed the recumbent posture the leucocyte count dropped according to rule and the basal level for the individual was reached in approximately an hour, and remained at this low level without variation for several hours provided the subject remained undisturbed; there was no rise after two or three hours, *i.e.*, there was no evidence of a digestive leucocytosis. In like manner a second mid-day meal in no way affected the return of the leucocyte count to the low basal level.

If one subject is given a heavy meal and the other goes entirely without food, the two show exactly the same variations of form if the individuals act in the same way, *e.g.*, lie down at the same time and rise for the ordinary activities of the day simultaneously. There is evidently no difference in level attributable to food.

What Dr. Garrey believes to be crucial experiments were conducted in the following way. Subjects, without breakfast, came into the laboratory. The first leucocyte counts showed the high activity level of about 9,000. The individuals then lay down and leucocyte counts were made every fifteen minutes for several hours. Within an hour the count was between 5,000 and 6,000 and the subject was then fed, in one series a protein meal, in another a carbohydrate meal of pancakes and syrup. Proteins are supposed to be especially potent in causing digestive leucocytosis and the subjects received two pounds of beefsteak, four eggs and two slices of toasted bread without fluid. In no single instance was there evidence of the slightest increase or variation in the number of circulating leucocytes, although the counts were continued for as much as four hours. If, however, the subjects for any reason assumed the erect posture there was an immediate increase due to postural change and activity, but upon assuming the recumbent posture the count fell again to the basal level within an hour.

Dr. Garrey concludes that there is no true digestive leucocytosis, and that the variations that have often been reported must be attributed to other forms of physiological activity which cause a vascular shift resulting in a redistribution of the blood and of the leucocytes already in the circulatory system.